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A

PRACTICAL WORKSHOP COMPANION

FOR

TIN, SHEET IRON,

AND

COPPER PLATE WORKERS.

CONTAINING

RULES FOR DESCRIBING VARIOUS KINDS OF PATTERNS USED BY TIN,
SHEET IRON, AND COPPER PLATE WORKERS;
PRACTICAL GEOMETRY;
Mensuration of Surfaces and Solids;
TABLES OF THE WEIGHTS OF METALS, LEAD PIPE, ETC.;
TABLES OF AREAS AND CIRCUMFERENCES OF CIRCLES;
JAPANS, VARNISHES, LACKERS, CEMENTS, COMPOSITIONS,
ETC., ETC., ETC.

By LEROY J. BLINN,
MASTER MECHANIC.

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CONTENTS.

RULES FOR DESCRIBING PATTERNS.

An Envelope for a Cone.......................... 3
A Frustrum of a Cone.......................... 4
A Can top or Deck flange.......................... 5
A Pattern for, or an Envelope for, a Frustrum of a Cone. 6
A Tapering Oval Article to be in four Sections......... 7
A Tapering Oval Article to be in two Sections...... 12, 13
A Tapering Oval Article.......................... 16
A Tapering Oval or Oblong Article, the sides to be Straight, with Quarter Circle corners, to be in two Sections.......................... 19
A Tapering Oval or Oblong Article, the sides to be Straight, one end to be a Semicircle, the other end to be Straight, with Quarter Circle corners, to be in two Sections.......................... 21
A Tapering Oval or Oblong Article, the sides to be Straight, with Semicircle ends, to be in two Sections.. 23
Covering of Circular Roofs.......................... 25
Two different Principles.......................... 25
To cover a Dome by the first Method................. 26
To cover a Dome by the second Method............... 27
To ascertain the Outline of a Course of Covering to a Dome, without reference to a Section of the Dome... 28
To describe a Pattern for a Tapering Square Article.... 29

A Square Tapering Article to be in two Sections....... 30
A Tapering Article, the Base to be Square, and the Top a Circle, in two Sections.......................... 31
A Tapering Article, the Base to be a Rectangle, and the Top Square, in two Sections...................... 32
A Tapering Article, the Base to be a Rectangle, and the Top a Circle, in two Sections...................... 34
A Tapering Article, the Top and Base to be a Rectangle, in two Sections.................................. 36
Tapering Octagon Top or Cover......................... 38
A Miter Joint at Right Angles for a Semicircle Gutter. 40
A Miter Joint at any Angle for a Semicircle Gutter..... 41
A Miter Joint for an O G Gutter at Right Angles..... 42
A Miter Joint for an O G Cornice at Right Angles; also an Offset... 44
An Octagon O G Lamp Top or Cover.................. 46
A T Pipe at Right Angles............................ 48
A T Pipe at any Angle................................ 50
A T Pipe, the Collar to be smaller than the Main Pipe.. 52, 54
A T Pipe at any Angle, the Collar to set on one side of the Main Pipe.................................... 56
A Pipe to fit a flat Surface at any Angle, as the Side of a Roof of a Building............................. 58
A Pipe to fit two flat Surfaces, as the Roof of a Building.. 60
An Elbow at Right Angles............................ 62
An Elbow Pattern at any Angle....................... 64
An Elbow in three Sections........................... 66
An Elbow in four Sections............................ 68
An Elbow in five Sections............................ 70
A Tapering Elbow...................................... 72
An Oval Boiler Cover.................................. 75
A Flange for a Pipe that goes on the Roof of a Building. 76
Octagon or Square Top or Cover...................... 78
Steamer Cover.. 79
An Ellipse or Oval, having two Diameters given........ 80

An Ellipse with the Rule and Compasses, the Transverse and Conjugate Diameters being given, that is the Length and Width.................................. 81
To find the Centre and the two Arcs of an Ellipse...... 82
To find the Radius and Versed Sine for a given Frustrum of a Cone.. 83
Practical Geometry.................................. 84
Decimal Equivalents to Fractional Parts of Lineal Measurement...................................... 91
Definitions of Arithmetical Signs...................... 92
Mensuration of Surfaces.............................. 93
Mensuration of Solids and Capacities of Bodies........ 102
Tables of Weights of Iron, Copper and Lead....... 106–110
Tables of the Circumferences and Areas of Circles.. 111–119
Sizes and Capacity of Tin-ware in form of Frustrum of a Cone, such as Pans, Dish Kettles, Pails, Coffee Pots, Wash Bowls, Dippers, Measures, Druggists' and Liquor Dealers' Measures.............................. 120–121
American Lap Weled Iron Boiler Flues................ 122
Table of Effects upon Bodies by Heat................. 122
Weight of Water..................................... 123
Effects produced by Water in an Aeriform State....... 123
Practical Properties of Water......................... 124
Effects produced by Water in its Natural State........ 124
Effects of Heat at certain Temperatures.............. 125
Tempering.. 125
Effects produced by Air in its Natural and in a Rarefied State.. 126
Table of the Expansion of Atmospheric Air by Heat... 126
Size, Length, Breadth and Weight of Tin Plates....... 127
Crystallized Tin Plate............................... 127
List of Calibre and Weights of Lead Pipe............. 128
Calibre and Weights of Fountains or Aqueauct Pipes... 128
To Ascertain the Weights of Pipes of various Metals, and any Diameter required.......................... 129
Weight of a Square Foot of Sheet Iron, Copper, and Brass, as per Birmingham Wire Gauge.............. 129
Recapitulation of Weights of Various Substances....... 130

PRACTICAL RECEIPTS.

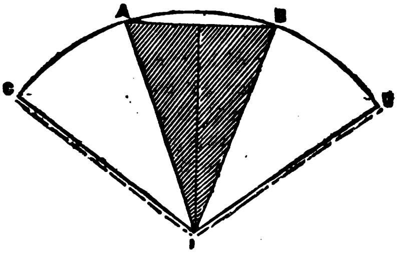
Japanning and Varnishing........................ 131–138
Varnishes—Miscellaneous 138–155
Lackers.. 155–157
Cements.. 158–162
Miscellaneous Receipts.......................... 163–166
Britannia...................................... 167–169
Solders, etc................................... 169–173
Strength of Materials.......................... 174–178

Rules for Describing Patterns.

A CONE.

To describe an Envelop for a Cone.

Fig. 1.

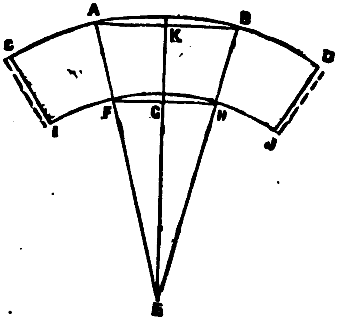


Let ABI be the given cone. From I as centre, with the radius IA, describe the arc CD; make CD; equal in length to the circumference of AB (which can be found by a reference to the table of the *Circumferences of Circles*;) draw the lines CI and DI; then the figure CDI will be that of the required surface of the cone.

Edges for folding or lapping to be allowed, drawing the lines paralled to CI and DI, as shown by the dotted lines.

To describe a Frustrum of a Cone.

Fig. 2.



Let AB equal diameter of large end; FH diameter of small end; GK altitude. Produce AF and BH until they meet at E; with E as centre, and the radii EF and EA, describe the arcs CD and IJ; set off CD equal to that portion of the circumference of AB required for a pattern; draw the lines CI and DJ, cutting the centre at E.

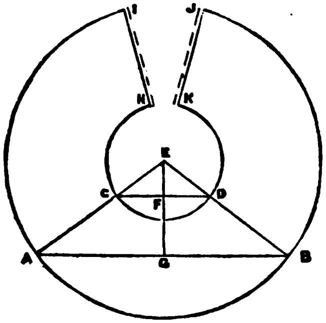
Edges for folding or lapping to be allowed, drawing the lines parallel to CI and DJ, as shown by the dotted lines.

Obs. The term altitude denotes perpendicular height; as from G to K in Fig. 2.

CAN TOP OR DECK FLANGE.

To describe a Can Top or Deck Flange.

Fig. 3.



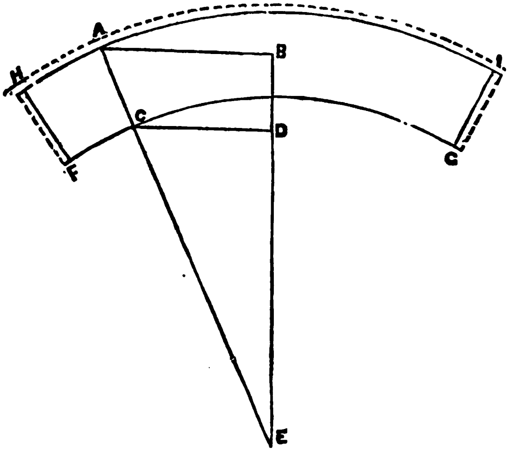
Let AB equal diameter of can, or base of a flange; CD diameter of opening in the top; FG altitude. Produce AC and BD until they meet at E; with E as centre, and the radii ED and EB, describe the curves IJ and HK; set off IJ equal to the circumference of the base AB; draw the lines IH and JK, cutting the centre at E.

Edges to be allowed.

FRUSTRUM OF A CONE.

To describe a Pattern for, or an Envelop for a Frustrum of a Cone.

Fig. 4.



Describe the right angle ABE; make BD the altitude; draw the line CD at right angle to BE; make AB equal one-half the diameter of the large end, CD one-half the diameter of the small end; draw a line cutting the points A and C, and the line BE with E as a centre and the radius EC and EA describe the arcs FG and HI; set off FG equal to that portion of the circumference of the smallest end required for a pattern, draw the lines HF and IG, cutting the centre at E.

Edges for folding or laping to be allowed drawing the lines parallel to HF and IG.

When the work is to be riveted, punch the holes for the rivets on the lines HF and IG.

When the work is to be wired, or a flange laid off, it must be allowed as shown by the dotted lines over the arc HI.

OVAL.

To describe a Pattern for a Tapering Oval article, to be in four Sections.

Describe the bottom, the length and breadth required as in fig. 5, describe the sides as in fig. 6 and 7.

Describe the right angle ABC, fig. 6; make BF the altitude, draw the line DF at right angle to BC; make DF equal to AB in fig. 5; make AB equal to DF and the taper required on a side, draw a line cutting the points A and D, and the line BC.

On any right line, as AB in fig. 7, with the radii CD and CA, describe the arcs EF and CD, set off EF equal to EBF in fig. 5; draw the lines CE and DF, cutting the centre at B.

Edges to be allowed.

Fig. 6, make EF equal to CD in fig. 5; make GB equal to EF, and the taper required on a side, draw a line cutting the points G and E, and the line BC.

On any right line, as AB in fig. 7, with the radii HE and HG, describe the arcs IK and GH; set off IK equal to FDG in fig. 5, draw the lines GI and HK, cutting the centre at L.

Edges to be allowed.

The taper must be equal on all sides.

Fig. 5.

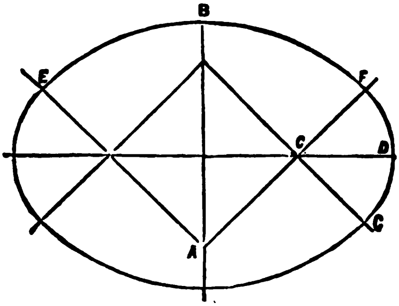


Fig. 6.

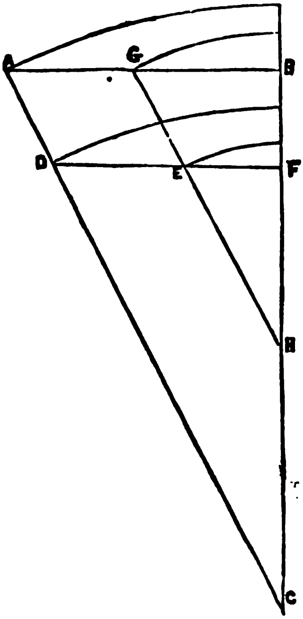


Fig. 7.

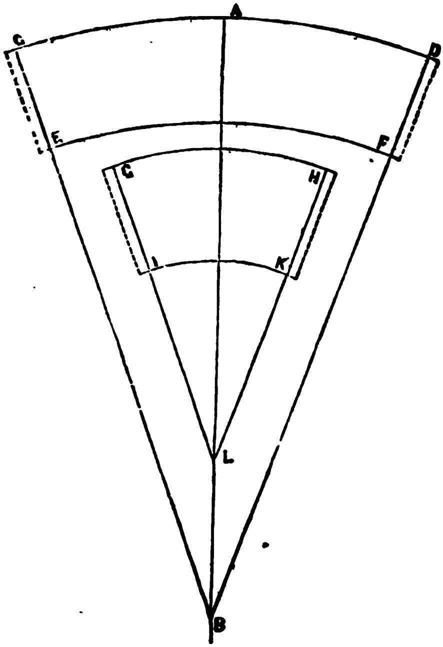


Fig. 8.

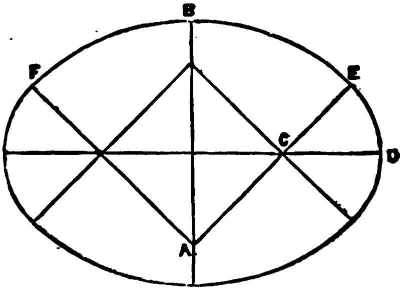


Fig. 9.

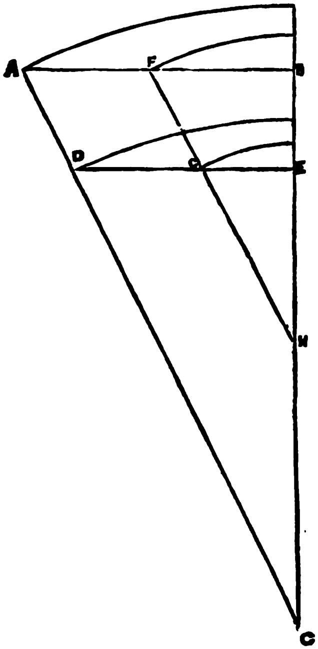
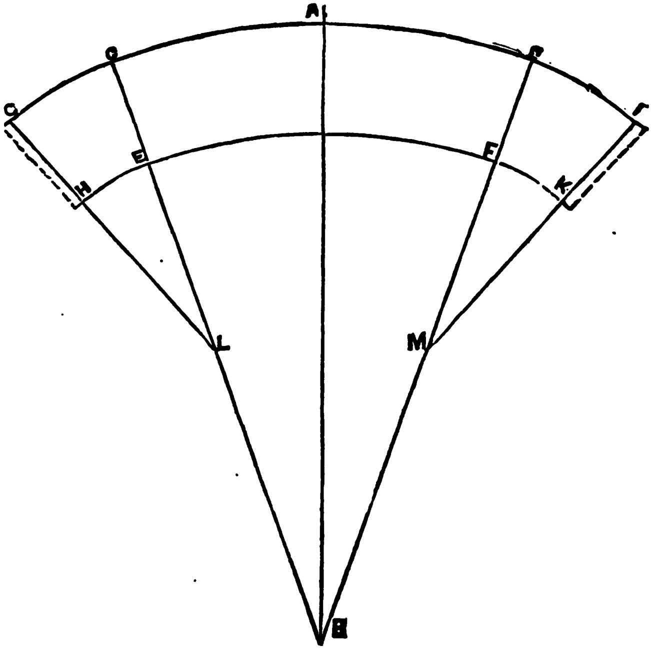


Fig. 10.



OVAL.

To describe a Pattern for a Tapering Oval article, to be in two Sections.

Describe the bottom, the length and breadth required as in fig. 8, then describe the body as in fig. 9 and 10.

Describe the right angle ABC, fig. 9; make BE the altitude, draw the line DE at right angle to BC; make DE equal to AB in fig. 8; make AB equal to DE and the taper required on a side, draw a line cutting the points A and D, and the line BC.

On any right line, as AB in fig. 10, with the radius CD and CA, describe the arcs EF and CD, set off EF equal to FBE in fig. 8; draw the lines CE and DF, cutting the centre at B.

Fig. 9, make GE equal to CD in fig. 8; make FB equal to GE, and the taper required on a side, draw a line cutting the points F and G, and the line BC, with the radius HG, and in fig. 10, E and F as centres, cut the lines CB and DB, as at L and M, with L and M as centres describe the arcs FK and EH; also, the arcs DI and CG; set off FK and EH, equal to ED in fig. 8; draw the lines IK and GH, cutting the centres at M and L.

Edges to be allowed.

The taper must be equal on all sides.

OVAL.

To describe a Pattern for a Tapering Oval article, to be in two Sections.

Describe the bottom, the length and breadth required as in fig. 11, then describe the body as in figs. 12 and 13; describe the right angle ABC, fig. 12; make BE the altitude, draw the line DE at right angle to BC; make DE equal to FC in fig. 11; make AB equal to DE and the taper required on a side, draw a line cutting the points A and D, and the line BC.

On any right line, as AB in fig. 13, with the radius CD and CA, describe the arcs CD and EF, set off CD equal to CD in fig. 11; draw the lines EC and FD, cutting the centre at B.

Fig. 12, make FE equal to AC in fig. 11; make GB equal to FE, and the taper required on a side, draw a line cutting the points G and F, and the line BC, with the radius JF, and in fig. 13, D as a centre, cut the line FB, as at K, with K as a centre describe the arc DH; also, the arc FG; set off DH equal to BC in fig. 11; draw the line GH, cutting the centre at K. Fig. 12, make HE equal to GE in fig. 11; make IB equal to HE, and the taper required on a side, draw a line cutting the points I and H, and the line BC with the radius KH, and in fig. 13, C as a centre, cut the line EB, as at L, with L as a centre, describe the arc IC; also, the arc JE; set off IC equal to DE, in fig. 11; draw the line JI, cutting the centre at L.

Edges to be allowed.

The taper must be equal on all sides.

Fig. 12.

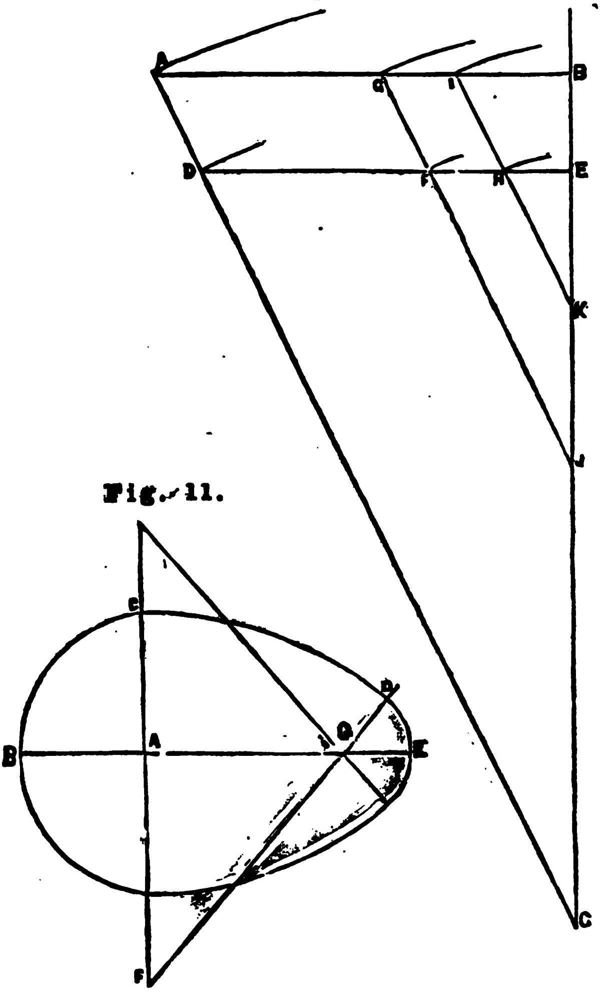
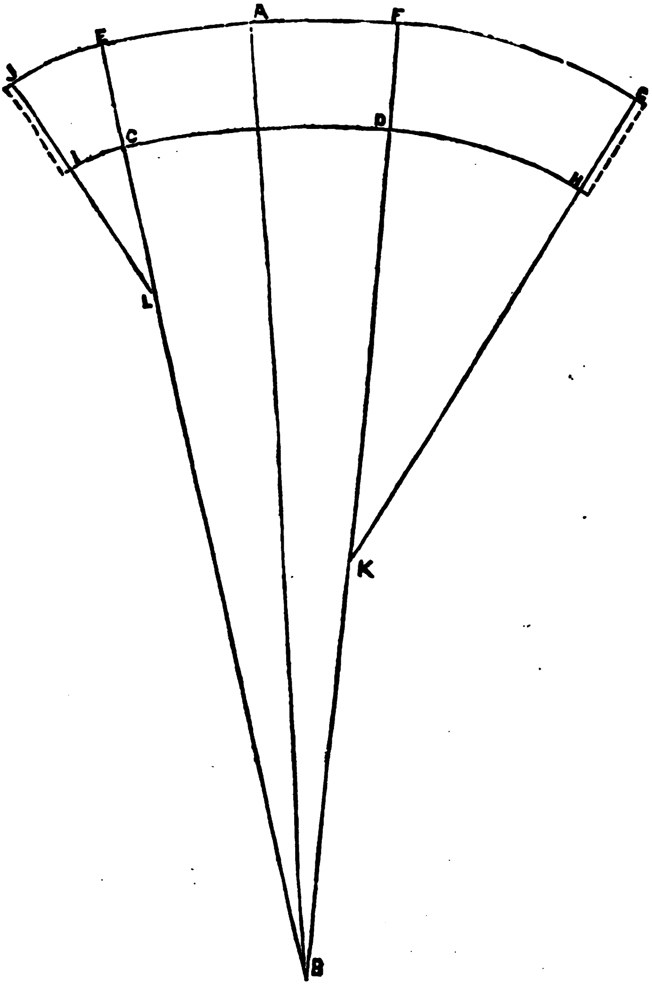


Fig. 11.

Fig. 13.



OVAL.

To describe a Pattern for a Tapering Oval article

Describe the bottom, the length and breadth required as in fig. 14; describe the body as in figs. 15 and 16; describe the right angle ABC, fig. 15; make BE the altitude, draw the line DE at right angle to BC; make FE equal to HG in fig. 14; make GB equal to FE and the taper required on a side, draw a line cutting the points G and F, and the line BC.

On any right line, as AB in fig. 16, with the radius HF and HG, describe the arcs CD and EF, set off CD equal to IGF in fig. 14; draw the lines EC and FG, cutting the centre at G.

Fig. 15, make DE equal to AB in fig. 14; make AB equal to DE, and the taper required on a side, draw a line cutting the points A and D, and the line BC, with the radius CD, and in fig. 16, with I and H as centres, cut the lines GL and GM, as at M and L, with M and L as centres; describe the arcs HI and HI; also, the arcs JK and JK; set off HI and HI equal to IB, in fig. 14; draw the lines JH and KI, cutting the centres L at and M. Fig. 15, make IE equal to CD in fig. 14; make JB equal to IE, and the taper required on a side, draw a line cutting the points J and I, and the line BC with the radius KI, and in fig. 16, O and N as centres, cut the lines LB and MB, as at R and S, with R and S as centres; describe the arcs NO and NO; also, the arcs PQ and PQ; set off NO and NO equal to BD in fig. 14; draw the lines QO and PN, cutting the centres at S and R.

Edges to be allowed.

The taper must be equal on all sides. The pattern can be cut in any number of sections.

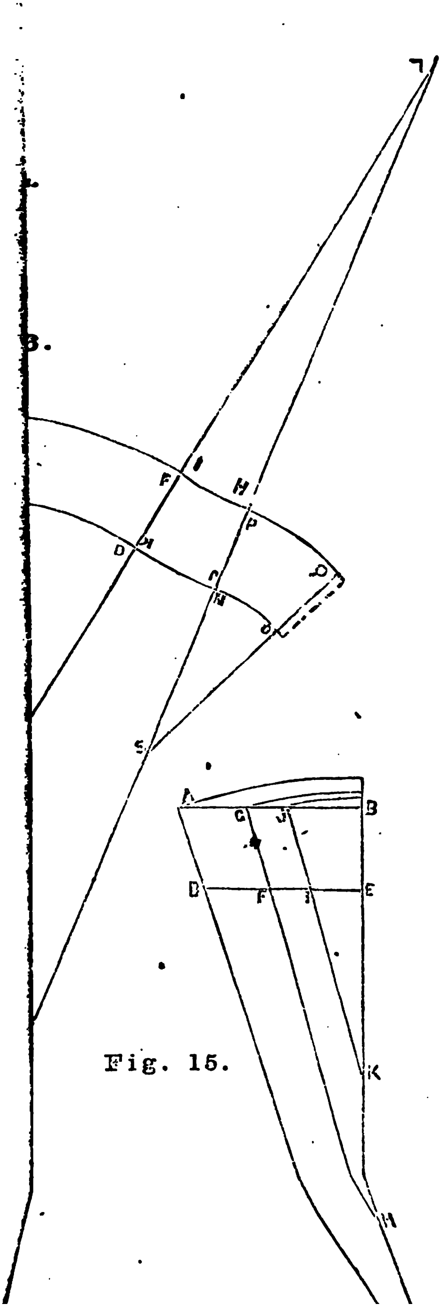


Fig. 15.

OVAL.

To describe a Pattern for a Tapering Oval or Oblong article, the sides to be Straight with Quarter Circle corners, to be in two Sections.

Describe the bottom, the length and breadth required as in fig. 17; the body as in figs. 18 and 19; describe the right angle ABC, fig. 18; make BE the altitude, draw the line DE at right angle to BC; make DE equal to EC in fig. 17; make AB equal to DE and the taper required on a side, draw a line cutting the points A and D and the line BC.

Fig. 19, make AD and BE equal to AD in fig. 18; make AB equal to AB in fig. 17; draw the lines DM and EN, fig. 18 with the radii CD, and in fig. 19, A and B as centres, cut the lines DM and EN, as at M and N, with M and N as centres; describe the arcs BC and AI; also, the arcs EF and DH; set off BC and AI equal to BC, in fig. 17; draw the lines HI and FC, cutting the centres M and N. Draw the lines FG and CL at right angle te FN; also, the line KH and JI at right angle to HM; make CL and JI equal to one-half off CD, in fig. 17, draw the lines KJ and GL at right angle to KH and FG.

Edges to be allowed.

The taper to be equal on all sides.

Fig. 19.

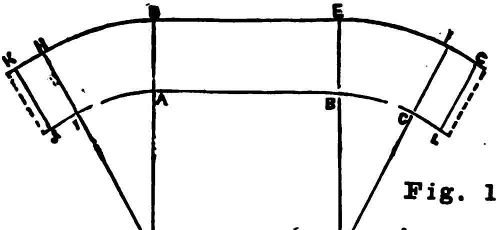


Fig. 18.

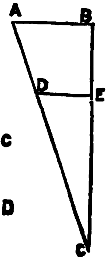
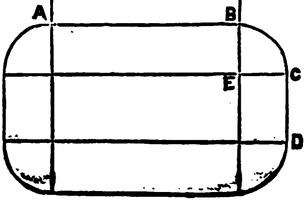


Fig. 17.



OVAL.

To describe a Pattern for a Tapering Oval or Oblong article, the sides to be Straight, one end to be a Semi-circle, the other end to be Straight with quarter Circle Corners, to be in Two Sections.

Describe the bottom, the length and breadth required as in fig. 20; the body as in figs. 21 and 22; describe the right angle ABC, fig. 21: make BG the altitude, draw the line DG at right angle to BC: make DG equal to AF in fig 20; make AB equal to DG and the taper required on a side, draw a line cutting the points A and D, and the line BC; make FG equal to GD in fig. 20; make EB equal to FG and the taper required on a side draw a line cutting the points E and F and the line B C.

Fig. 22, make AC and BD equal to DA in fig. 21; make CD and AB equal to BC in fig. 20; draw the lines CK and DL. Fig. 21; with the radii CD, and in fig. 22; A as a centre, cut the line CK as at K with K as a centre; describe the arc AI, also, the arc CJ; set off AI equal to AB, in fig. 20, draw the line JI, cutting the centre at K.

Fig. 21, with the radii HF, and in fig. 22, B as a centre cut the line DL, as at L, with L as a centre; describe the arc BF, also the arc DE; set off BF equal to CD, in fig. 20; draw the line EF, cutting the centre at L; draw the lines FG and EH at right angle to EL; make FG, equal to DE, in fig. 20; draw the line HG at right angle to EH.

Edges to be allowed.

The taper to be equal on all sides.

Fig. 22.

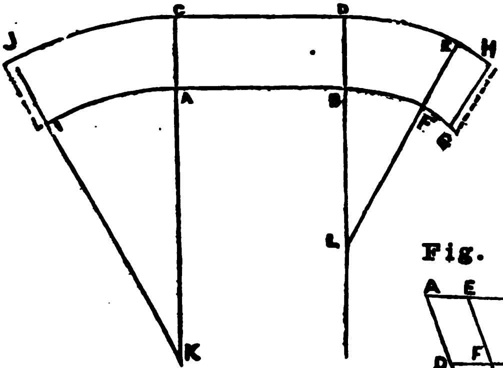


Fig. 21.

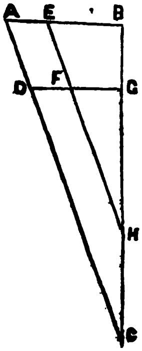
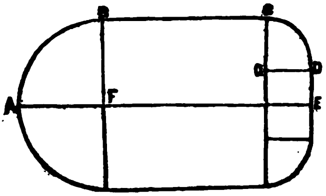


Fig. 20.



OVAL.

To describe a Pattern for a Tapering Oval or Oblong article, the sides to be Straight, with Semicircle ends, to be in Two Sections.

Describe the bottom, the length and breadth required as in fig. 23; the body as in figs. 24 and 25.

Describe the right angle ABC, fig. 24: make BE the altitude, draw the line DE at right angle to BC: make DG equal to AB in fig 23; make AB equal to DE and the taper required on a side, draw a line cutting the points A and D, and the line BC, fig. 25; make AC and BD equal to AD in fig. 24.

Make AB and CD equal to DC in fig. 23; draw the lines CI and DJ, fig. 24; with the radii CD, and in fig. 25; A and B as centres, cut the lines CI and DJ as at I and J, with I and J as centres; describe the arcs AH and BF; also, the arcs CG and DE; set off AH and BF equal to CB, in fig. 23, draw the lines GH and EF, cutting the centre at I and J.

Edges to be allowed.

The taper to be equal on all sides.

In a large article it may be more convenient to lay out the End-pieces to fit the Semi-circles, and join them to the sides, as at D and C, in fig. 23.

Fig. 25.

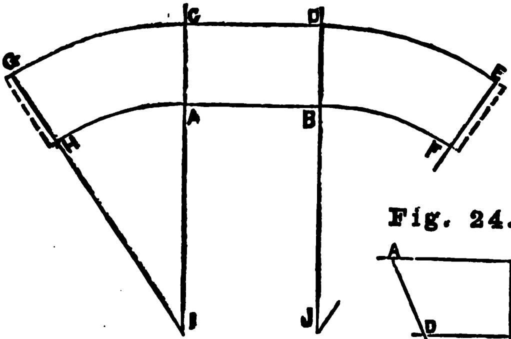


Fig. 24.

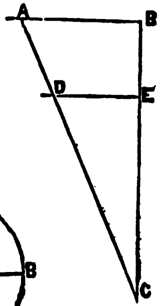
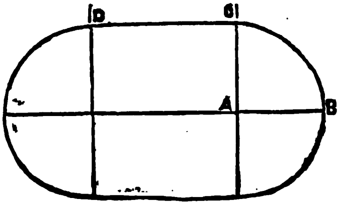


Fig. 23.



COVERING OF CIRCULAR ROOFS, &c.

Circular Roofs may be covered upon two different principles :

First Method.

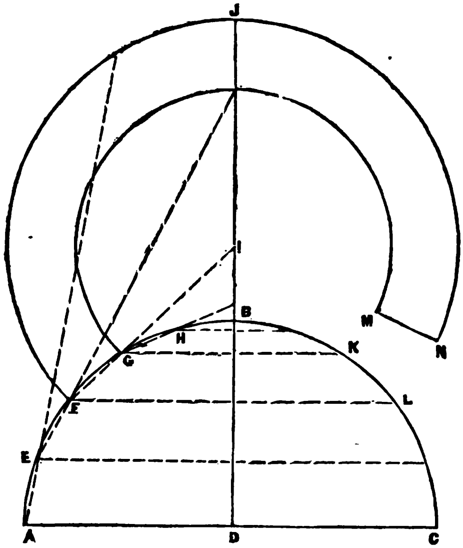
Assume the vertical section, or axis, to be divided into a number of equal parts, and the roof, or figure, cut by planes through the points of division parallel to the base; and then consider the portions of the figure as so many frustrums of a cone; the surface of each frustrum can then be determined as by fig. 26, page 26.

Second Method.

Divide the circumference of the base into a number of equal parts, and assume sections to be made perpendicular through these points of division; then estimate the surface of each of these divisions on the surface of the figure.

To Cover a Dome by the First Method.

Fig. 26.

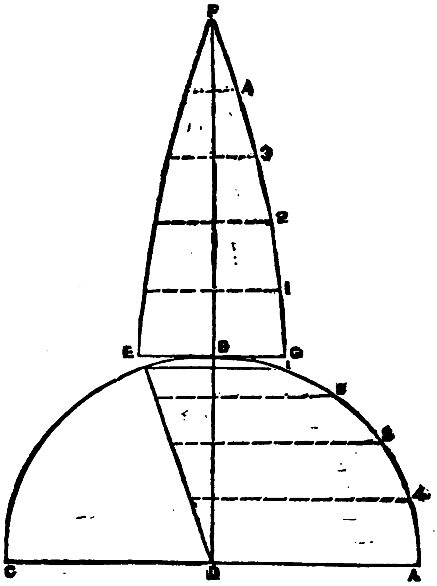


Let ABC, fig. 26, be the section of a dome. Draw the axis DB; produce to J; divide the curve of one-half the figure into equal parts, as EFG and H, the width of these divisions being the width required by that of the metal with which the dome is to be covered; produce AE, EF, FG, GH, and HB, severally until they intersect the axis BD; then [for example] from the point I, with the radii IG and IF, describe the curves GM, FN; then set off that portion of the circumference of the base FL required for a pattern to cover the course FG.

In the same manner, the covering for the other portion can be found.

To Cover a Dome by the Second Method.

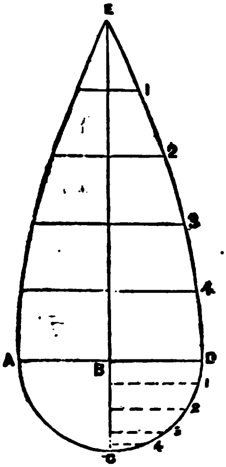
Fig. 27.



Let ABC, fig. 27, be the section of a dome; then the length of a course of covering is obtained as follows: The length of the course BF is equal to the curve AB, and EG the breadth of it; join ED, and the lines 1, 2, 3, and 4, intersected thereby, will be the half breadth (for the vertical BD) of the course at the corresponding lines on BF, through which points a line can be drawn which will give the form of the course required.

To ascertain the Outlines of a Course of Covering to a Dome, without reference to a Section of the Dome.

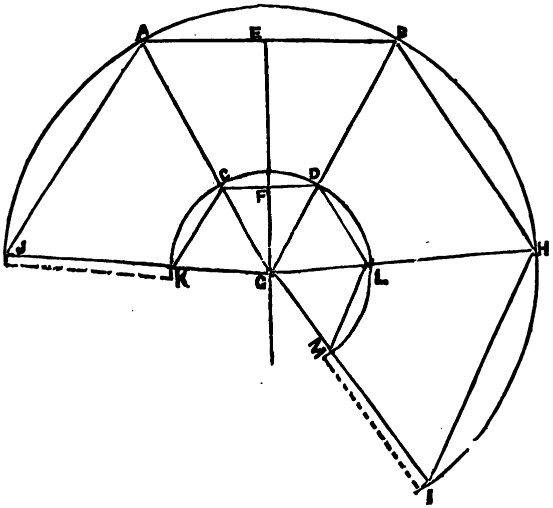
Fig. 28.



Let AB be the breadth of the course. Bisect it at B by the perpendicular CE; make BE equal to the length of the arc from the base of the dome to the top of it (which may be found either by measurement or calculation); divide the semi-circle ACD into any number of equal parts, and draw the lines parallel to BD; divide BE into the same number of equal parts, and draw lines parallel to AD; mark ordinates on each side of BE; as 1, 2, 3, and 4 equal to the lines of BCD, and a curve drawn through their terminations 1, 2, 3, and 4 on both sides will give the outline of the course.

To describe a Pattern for a Tapering Square Article.

Fig. 29.



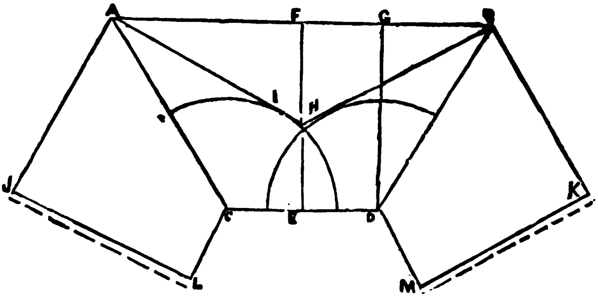
Erect the perpendicular line GE; draw the line AB at right angle to GE; make EF equal to the Slant height, and draw the line CD parallel to AB; make AB equal in length to one side of the base; make CD equal in length to one side of the top or smallest end, draw the lines AG and BG, cutting the points AC and BD, G as a centre with the radii GC and GA. Describe the arcs KM and JI; set off on the arc JI, JA, BH, and HI equal in length to AB, and draw the lines JG, HG, and IG, also, the lines JA, BH, HI, and KC, DL, LM.

Edges to be allowed.

SQUARE.

To describe a Pattern for a Square Tapering article, to be in Two Sections.

Fig. 30.



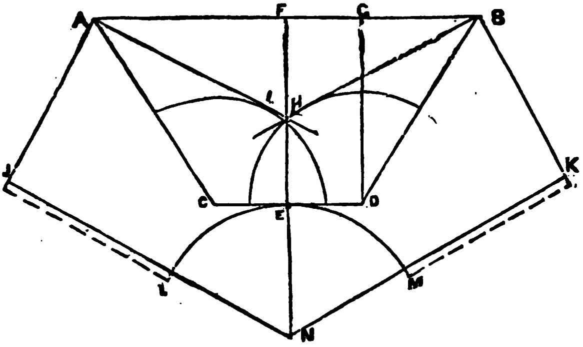
Erect the perpendicular line EF equal to the Slant height of the articles; draw the line AB at right angle to EF; draw the line CD parallel to AB; make AB equal in length to one side of the base; make CD equal in length to one side of the top or smallest end; draw the lines AC and BD, C and D as centres, with a radii equal to one-half the difference of the two ends, as from B to G; describe the arcs I and H; draw the right angle lines IAJ and HBK; set off JA and KB equal to FB, and draw the lines JL and KM at right angles to JA and KB; also, the lines LC and MD at right angles to LJ and MK.

Edges to be allowed.

SQUARE BASE WITH A CIRCULAR TOP.

To describe a Pattern for Tapering article, the Base to be Square, and the Top a Circle to be in two Sections.

Fig. 31.



Erect the perpendicular line NF; draw the line AB at right angle to NF; make EF equal to the Slant height, and draw the line CD parallel to AB; make a AB equal in length to one side of the base; make CD equal in length to one-fourth the circumference of the top, and draw the lines AC and BD, C and D as centres, with a radii equal to one-half the difference of the two ends; describe the arcs I and H, draw the right angle lines IAJ and HBK; set off JA and KB equal to FB, and draw the lines JN and KN at right angles to JA and KB, N as a centre with the radii NE describe the arc LEM.

Edges to be allowed.

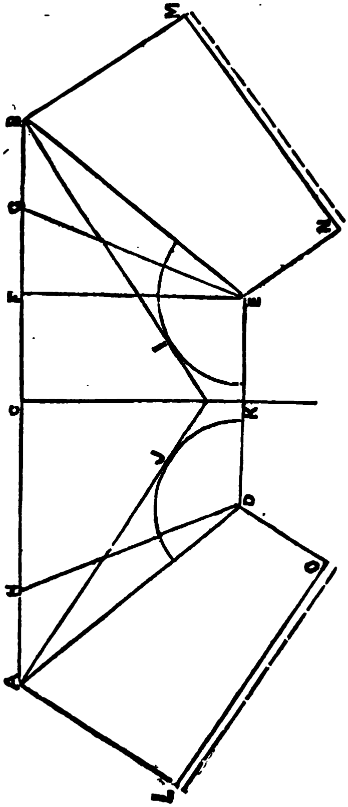
RECTANGLE BASE WITH A SQUARE TOP.

To describe a Pattern for a Tapering article, the Base to be a Rectangle, and the Top Square, to be in Two Sections.

Erect the perpendicular line KC, fig. 32; draw the line AB at right angle to KC; make KC equal to the Slant height, and draw the line DE parallel to AB; make AB equal in length to the longest side of the base; make DE equal in length to one side of the top; draw the lines AD and BE; make CG equal to one-half the shortest side of the base, D and E as centres, with a radii equal to one-half the difference of the top and the shortest side of the base, as from G to F; describe the arcs J and I; draw the right angle lines JAL and IBM; set off AL and BM equal in length to CG, and draw the lines MN and LO at right angle to BM and LA; also, the lines NE and OD at right angle to NM and OL.

Edges to be allowed.

Fig. 32.



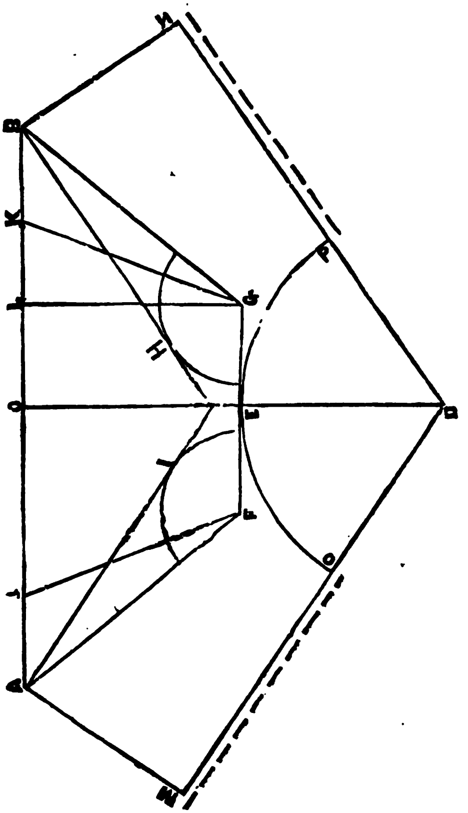
RECTANGLE BASE WITH A CIRCULAR TOP.

To describe a Pattern for a Tapering Article, the Base to be a Rectangle, and the Top a Circle, to be in Two Sections.

Erect the perpendicular line DC, fig 33; draw the line AB at right angle to DC; make CE equal to the Slant height, and draw the line FG parallel to AB; make AB equal in length to the longest side of the base; make FG equal in length to one-fourth the circumference of the top; draw the lines AF and BG; make CK equal to one-half the shortest side of the base; erect the line LG parallel to EC, F and G as centres, with the radii KL. Describe the arcs I and H; draw the right angle lines HBN and IAM; set off BN and AM equal in length to CK, and draw the lines MD and ND at right angles to MA and NB, D as a centre with the radii DE, describe the arc OED.

Edges to be allowed.

Fig. 33.



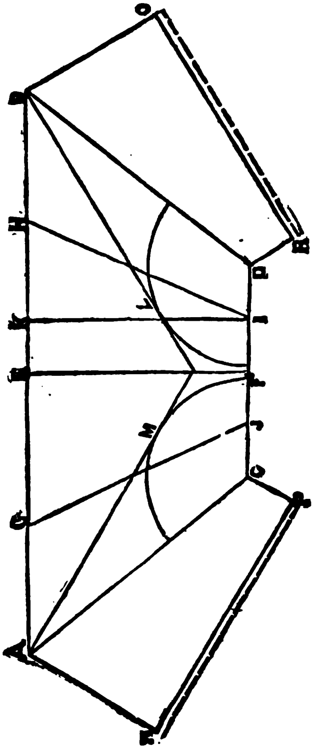
RECTANGLE.

To describe a Pattern for a Tapering Article, the Top and Base to be a Rectangle, to be in Two Sections.

Erect the perpendicular line FE, fig. 34; draw the line AB at right angle to FE; make FE equal to the slant height of the article, and draw the line CD parallel to AB; make AB equal in length to the longest side of the base; make CD equal in length to the longest side of the top; draw the lines AC and BD; make GH equal in length to the shortest side of the base; make JI equal in length to the shortest side of the top; draw the line HI, also, erect the line KI parallel to FE, C and D as centres, with the radii HK; describe the arcs M and L; draw the right angle lines LBO, and MAN; set off BO and AN equal in length to EH, and draw the lines OR and NP at right angles to OB and NA; also, the lines RD and PC at right angles to RO and IN.

Edges to be allowed.

Fig. 34.



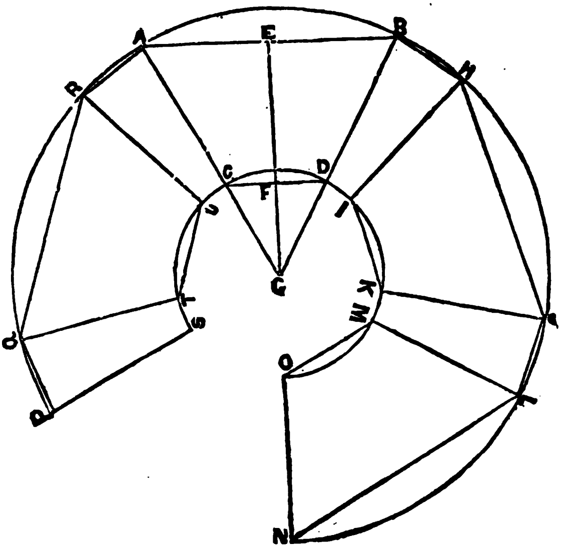
OCTAGON.

To describe a Pattern for Tapering Octagon Top or Cover.

Erect the perpendicular line GE, fig. 35; draw the line AB at right angle to GE; make FE equal to the Slant height of the article, and draw the line CD parallel to AB; make AB equal in length to one of the longest sides of the base; make CD equal in length to one of the longest sides of the top, and draw the lines AG and BG, cutting the points AC and BD, G as a centre, with the radii GC and GA describe the arcs SO and PN; set off QR, HJ and LN equal to AB; set off PQ, RA, BH and JL equal in length to one of the shortest sides of the base; draw the lines PS, QT, RU, &c., cutting the centre at G. draw the lines PQ, QR, ST, TU, &c.

Edges to be allowed.

Fig. 35.



GUTTER MITER JOINTS.

To describe a Pattern for a Miter Joint at Right angles for a Semicircle Gutter.

Fig. 36.

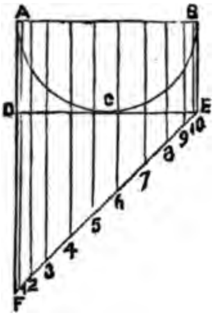
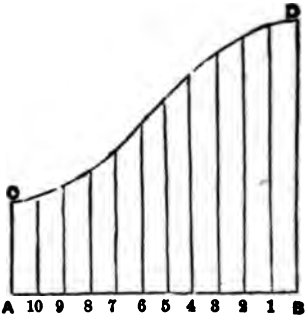


Fig. 37.



Let the semi-circle ACB, fig. 36, be the breadth and depth of the gutter; draw the line AB; draw the lines AF and BE at right angle to AB; draw the line DE parallel to AB; make DF equal to AB, and draw the line FE; devide the semi circle into any number of equal parts from the points; draw lines parallel to AF as 1, 2, 3, &c., then set off the line AB, fig. 37, equal in length to the semi circle ACB; erect the lines BD and AC at right angle to AB; set off on on the line AB, fig. 37, the same number of equal distances as in the semicircle from the points; draw lines parallel to BD, as 1, 2, 3, &c., make BD equal in length to AF, fig. 36; and AC equal in length to BE; also, each of the parallel lines bearing the same figure as 1, 2, 3, &c., then a line traced through the points will form the pattern required.

MITER JOINTS.

To describe a Pattern for a Miter Joint at any Angle for a Semi-circle Gutter.

Fig. 38.

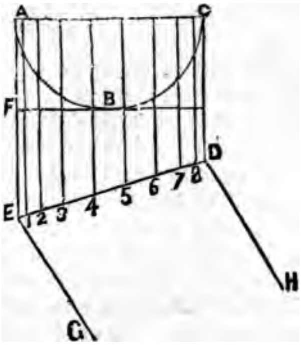
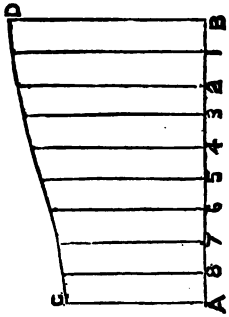


Fig. 39.



Let ABC, fig. 38, be the breadth and depth of the gutter; draw the line AC; draw the lines EG and DH; the angle required draw the line ED cutting the points E and D; divide the semicircle into any number of equal parts, from the points draw lines parallel to AE, as 1, 2, 3, &c. Then set off the line AB, fig. 39, equal in length to the semicircle ABC; erect the lines AC and BD at right angle to AB; set off on the line AB, the same number of equal distances as in the semi-circle ABC; from the points draw lines parallel to BD, as 1, 2, 3, &c. Make BD equal to EA, and AC equal to DC; also, each of the parallel lines bearing the same figures as 1, 2, 3, &c., then a line traced through the points will form the pattern.

MITER JOINTS.

To describe a Pattern for a Miter Joint for an O G Gutter at Right Angles.

Let ABCD, fig. 40, be the given gutter; divide the curved line BC into any number of equal parts from the points; draw lines parallel to AD, as 1, 2, 3, &c.; then set off the right angle line ABE, fig. 41; make BF equal to AB, and draw the line CF parallel to AB; make AB and CF equal in length to AD, and draw the line AC; make FD, equal in length to the curved line BC; set off on the line FD the same number of equal distances, as in the curved line BC; from the points draw lines parallel to CF, as 1, 2, 3, &c.; make CF equal to BE, also, each of the parallel lines bearing the same figures, as 1, 2, 3, &c.; make DE equel to CD, then a line traced through the points will form the pattern.

Fig. 41.

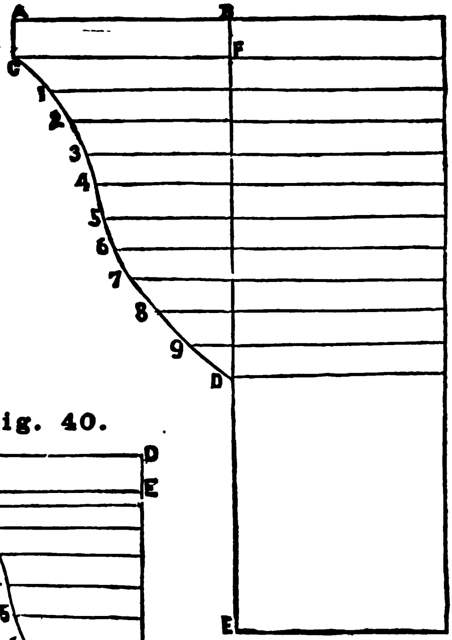
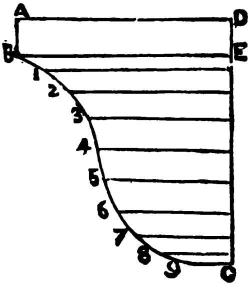


Fig. 40.



CORNICE.

To describe a Pattern for a Miter Joint for an O G Cornice at Right angles, also an Offset.

Describe the right angle line AFE, fig. 42; let ABCDE be the given cornice; divide the curved line BCH into any number of equal parts; from the points draw lines parallel to AF, as 1, 2, 3, &c. Then set off the right angle ABCF, fig. 43; make CD equal to AB; make DG equal in length to the curved line BCH; make GE equal to HD; make EF equal to DE; set off on the line DG the same number of equal distances as in the curved line BCH; from the points draw lines parallel to BC, as I, 2, 3, K, H, &c. Make BC and ID cqual to AF; also, each of the parallel lines bearing the same figures as 2, 3, 4, &c.; make KG and HE equal to DE; then a line traced through the points B, I, 2, 3, 4, &c.; KHF will form the pattern for a Miter Joint.

When there is to be an offset or projection at right angles, let AB, fig. 44, be the depth of the offset or projection; make each of the parallel lines the same in length as AB, LI, 22, 33, &c., then a line traced through the points will form the pattern.

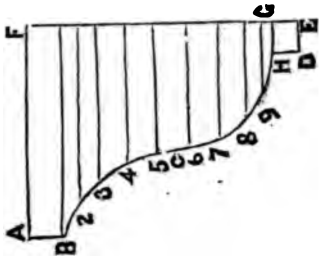


Fig. 42.

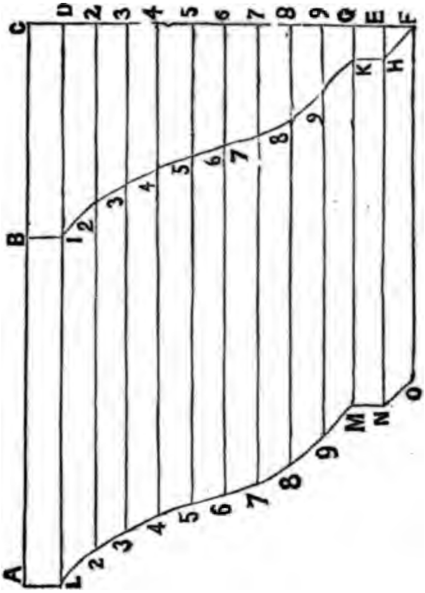


Fig. 44.

Fig. 43.

OCTAGON.

To describe a Pattern for an Octagon O G Lamp Top or Cover.

Describe a circle that will cut the required Octagon, fig. 45; draw a line that will cut the centre of two sections, as AI; erect the perpendicular line HF; let ABCDEFJ be the given top or cover; divide the curved lines BC and EF into any number of equal parts; from the points draw lines parallel to FH, as 1, 2, 3, &c., H, 1, 2, 3, &c.

Set off the line AF, fig. 46; draw the line GE at right angle to AF; make AB equal to AB in fig. 45; make BC equal in length to the curved line BC; divide BC into the same number of equal distances, as in the curved line BC; from the points draw lines parallel to GE; make CD equal to CD, and DH equal to DE; make HF equal to the curved line EF; divide HF into the same number of equal distances, as in the curved line EF; from the points draw lines parallel to GE; make AGAE and BIBJ equal to GA; also, each of the parallel lines bearing the same figures as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 10, H, 1, 2, 3, 4, 5, 6; then a line traced through the points will form the pattern.

A Top may be described in any number of Sections by this Rule.

Fig. 45.

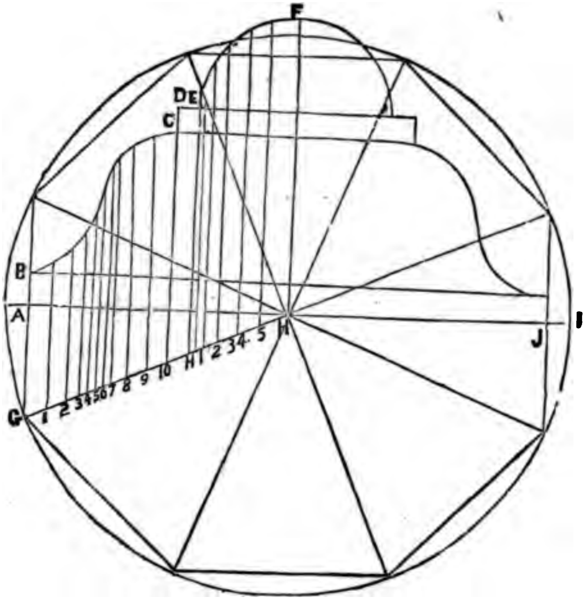
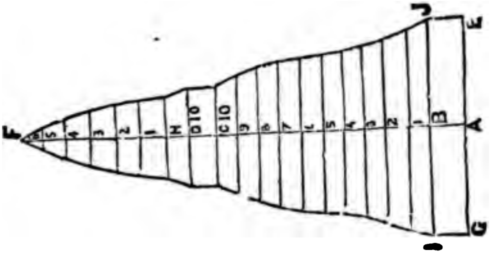

F
DE
C
B
A
H
I
J
G
1 2 3 4 5 6 7 8 9 10 H 1 2 3 4 5

Fig. 46.


J
E
F
6 5 4 3 2 1 H
D10
C10
9 8 7 6 5 4 3 2 1
B
A
G
D

PIPES.

To describe a T Pipe at Right angles.

Let ABCD, fig. 47, be the length and diameter of the T; describe the semi-circle CED; divide the semicircle into any number of equal parts; from the points draw lines parallel to AC, as 1, 2, 3, &c.; then set off the line ABC, fig. 48, equal in length to the circumference of the Pipe AB; erect the lines AD, BE and CF; set off on each side of BE the same number of equal distances, as in the semi-circle CED; from the points draw lines parallel to BE, as 11, 22, 33, &c.; make AD, BE and CF equal to AC; also, each of the parallel lines, bearing the same numbers as 11, 22, 33, &c.; then a line traced through the points will form the pattern required.

Edges to be allowed for folding or riveting.

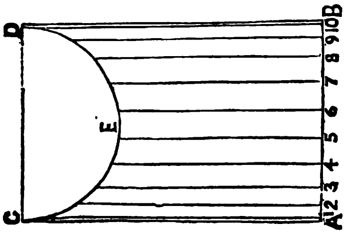


Fig. 47.

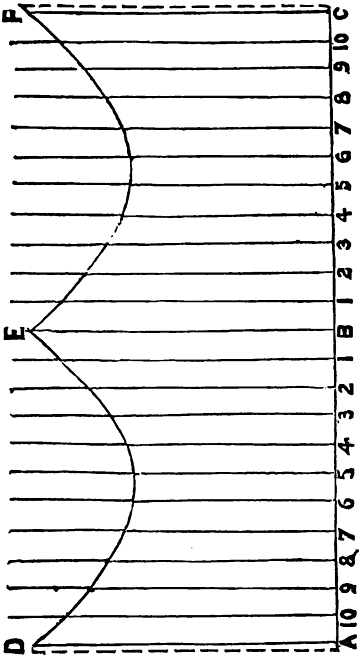


Fig. 48.

PIPES.

To describe a Pattern for a T Pipe at any angle.

Draw the line AE, fig. 49; erect the line AB, the angle required; also, the line ED parallel to AB; make BD equal to the diameter of the Pipe; describe the semicircle BCD; draw the line FG parallel to BD; divide the semicircle into any number of equal parts from the points; draw lines parallel to AB, as 1, 2, 3, &c.

Set off the line ABC, fig. 50, equal in length to the circumference of the Pipe; erect the lines AE, BD and CF at right angles to AC; set off on each side of BD the same number of equal distances, as in the semicircle BCD, and from the points draw lines parallel to BD, as 11, 22, 33, &c. Make BD equal to AB, and EA and CF equal to ED; also, each of the parallel lines, bearing the same figures as 11, 22, 33, &c. Make GI and HJ equal to GD; also, each of the lines bearing the same figures as 11, 11, 22, 22, &c.; then a line traced through the points will form the required pattern.

Edges to be allowed.

Fig. 49.

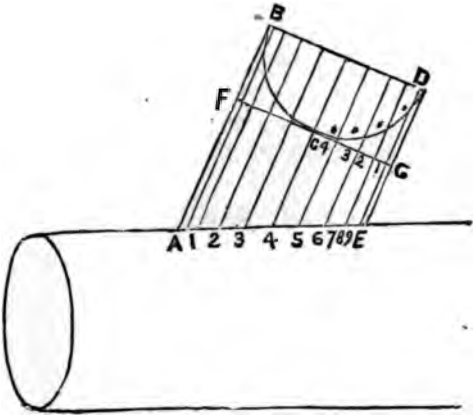
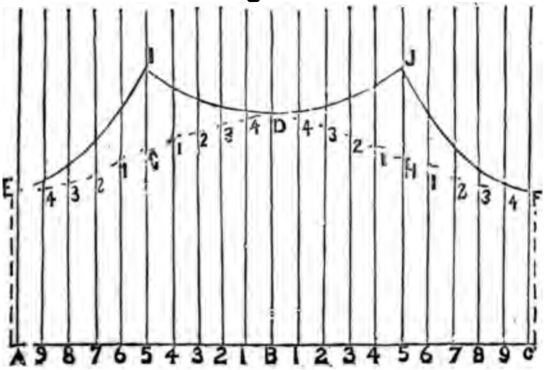

B
D
F
C 4
3 2
1
G
A 1 2 3 4 5 6 7 8 9 E

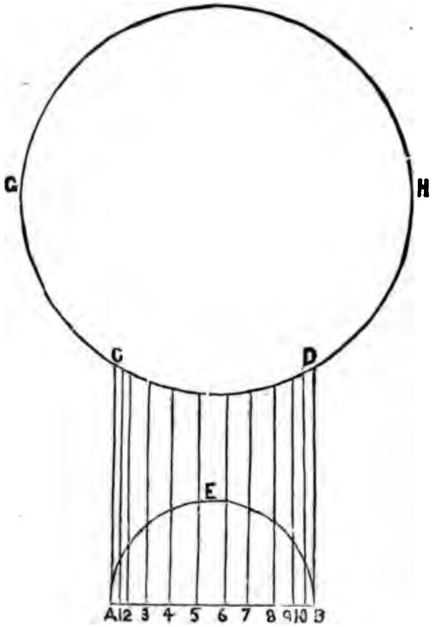
Fig. 50.


I
J
D
C
H
E
F
4 3 2 1
1 2 3 4
4 3 2 1
1 2 3 4
A 9 8 7 6 5 4 3 2 1 B 1 2 3 4 5 6 7 8 9 C

PIPES

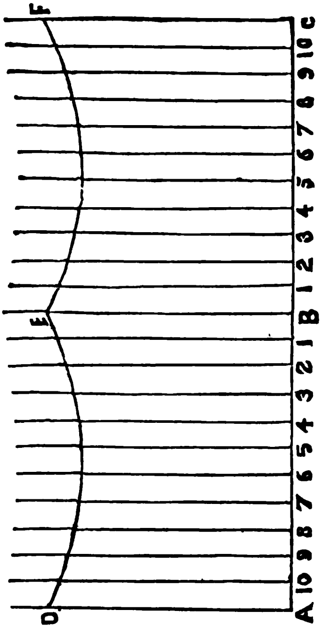
To describe a Pattern for a T Pipe, the Collar to be Smaller than the Main Pipe.

Fig. 51.



Let the circle GH, fig. 51, equal the large pipe, AB, CD, the Branch or Collar; describe the semicircle AEB; divide the semicircle into any number of equal parts; from the points, draw lines parallel to AC, as 1, 2, 3, &c.

Fig. 52.



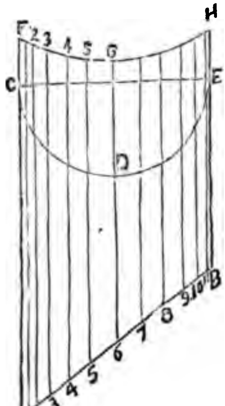
Set off the line ABC, fig. 52, equal in length to the circumference of the Collar AB ; erect the perpendicular lines AD, BE and CF; set off on each of BE, the same number of equal distances as in the semicircle; from the points draw lines parallel to BE, as 1, 1, 2, 2, &c. ; make AD, BE and CF equal to AC and BD; also, each of the parallel lines bearing the same figures as 1, 1, 2, 2, 3, 3, &c., then a line traced through the points will form the pattern.

Edges to be allowed.

PIPES.

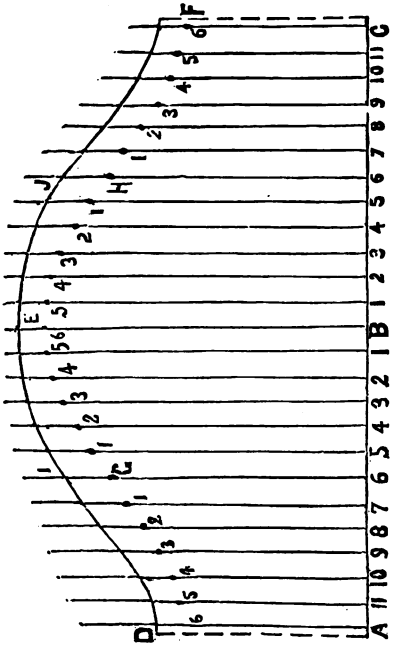
To describe a Pattern for a T Pipe at any angle, the Collar to be Smaller than the Main Pipe.

Fig. 53.



Let CE, fig. 53, be the diameter of the collar, and AB the angle required; describe the semicircle CDE; make CF and EH of equal length, with a radii equal to one-half the diameter of the large pipe; describe the arc FH; divide the semicircle into any number of equal parts; from the points draw lines parallel to AC, as 1, 2, &c. There must be an odd number of lines, as in the diagram, so that one of the lines run through the centre of the semicircle.

Fig. 54.



Set off the line ABC, fig. 54, equal in length to the circumference of the collar, CE; erect the lines AD, BE and CF; set off on each side of BE the same number of equal distances, as in the semicircle, and from the points draw lines parallel to BE, as 11, 22, &c.; make BE equal to AC in fig. 53; make AD and CF equal to BE; also, each of the parallel lines bearing the same figures; make GI and HJ equal to CF; also, each of the parallel lines bearing the same figures as 11, 11, 22, 22, &c.

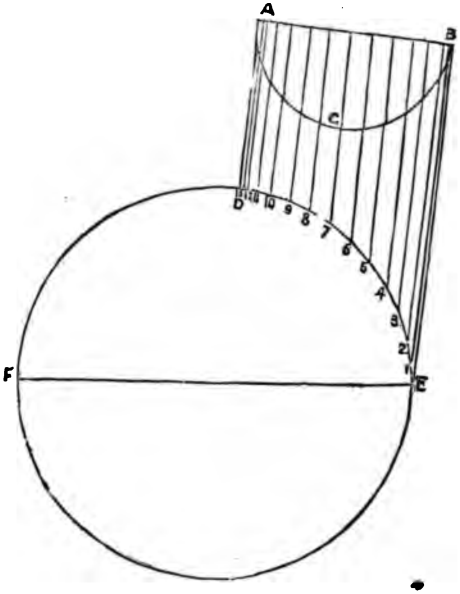
A line traced through the last points will form the pattern,

Edges to be allowed.

PIPES.

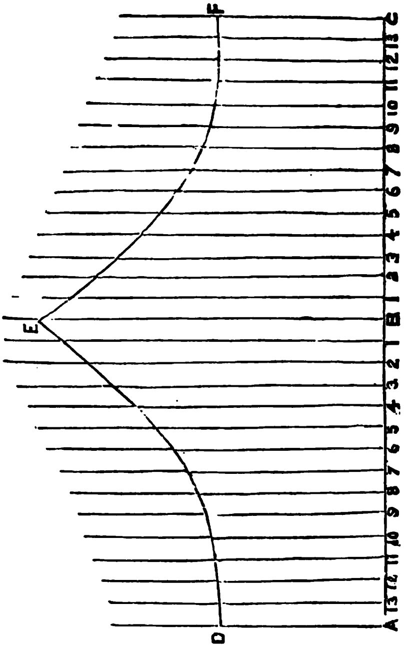
To describe a Pattern for a T Pipe at any angle, the Collar to set on one side of the Main Pipe.

Fig. 55.



Let the circle FE, fig. 55, equal large pipe or boiler; make AB equal to the diameter of the collar or branch pipe, BE the angle required; describe the semicircle ACB; divide the semicircle into any number of equal parts; from the points draw lines parallel to BE, as 1, 2, 3, &c.

Fig. 56.



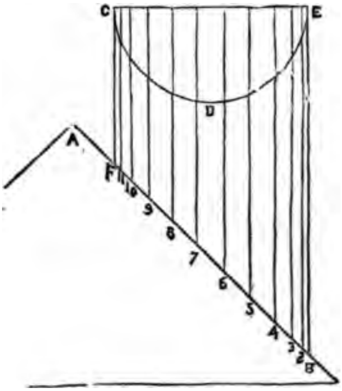
Set off the line ABC, fig. 56, equal in length to the circumference of the collar AB; erect the perpendicular lines AD, BE and CH; set off on each side of BE the same number of equal distances, as in the semicircle ACB; from the points draw lines parallel to BE; make BE equal to EB; make AD and CF equal to DA; also, each of the parallel lines bearing the same figures as 11, 22, 33, &c.; then a line traced through the points will form the pattern.

Edges to be allowed.

PIPES.

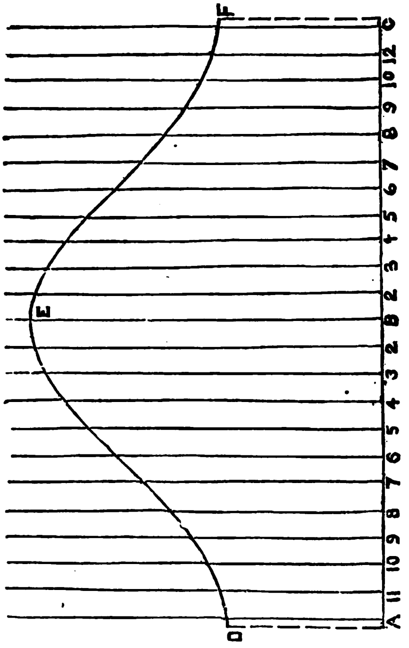
To describe a Pattern for a Pipe to fit a Flat Surface at any Angle, as the side of the Roof of a Building.

Fig. 57.



Let AB, fig. 57, equal the angle of the roof of a building; let CE, FB equal the pipe; draw the line CE; describe the semicircle CDE; divide the semicircle into any number of equal parts; from the points draw lines parallel to EB, as 2, 3, 4, &c.

Fig. 58.



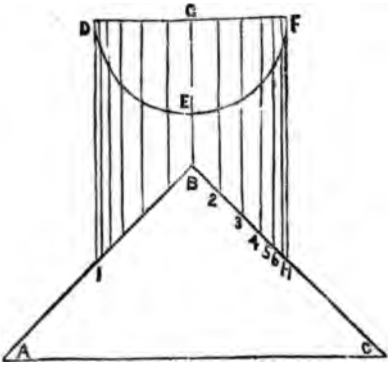
Then set off the line ABC, fig. 58, equal in length to the circumference of the cylinder CE; erect the perpendicular lines AD, BE and CF; set off on each side of BE the same number of equal distances, as in the semicircle CDE; from the points draw lines parallel to BE; make BE equal to BE; make AD and CF equal to FC; also, each of the parallel lines bearing the same number as 22, 33, 44, &c.; then a line traced through the points will form the pattern.

Edges to be allowed.

PIPES.

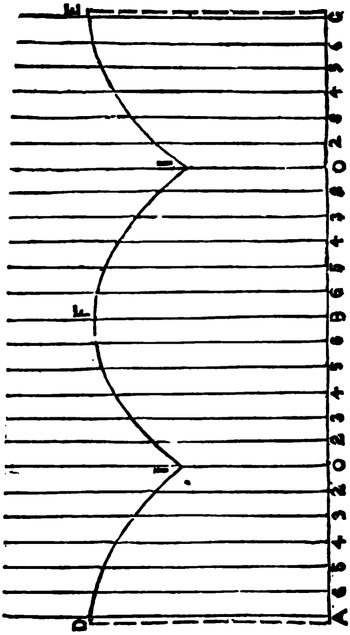
To describe a Pattern for a Pipe to fit two Flat Surfaces, as the Roof of a Building.

Fig. 59.



Let ABC, fig. 59, equal the pitch of a roof; let DF, IH, be the pipe; draw the line BG parallel to HF; draw the line DF at right angle to HF; describe the semicircle DEF; divide one-half the semicircle into any number of equal parts; from the points draw lines parallel to FH, as 2, 3, 4, &c.

Fig. 60.



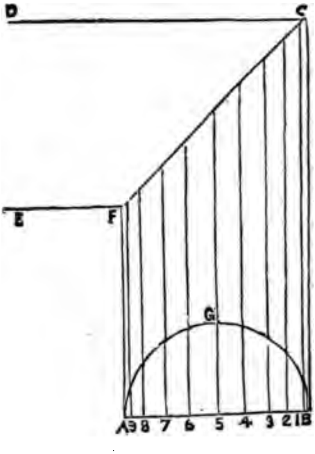
Set off the line ABC, fig. 60, equal in length to the circumference of the pipe DF; divide the line ABC into four equal parts, and erect the lines AD, OI, BF, OI, CE; set off on each side of OI, OI, the same number of equal distances as in one-half the semicircle; from the points draw lines parallel to BF; make AD, BF and CE equal to HF; make OI, OI equal to BG; also, each of the parallel lines bearing the same figures as 22, 22, 33, 33 &c.; then a line traced through the points will form the pattern

Edges to be allowed.

ELBOWS.

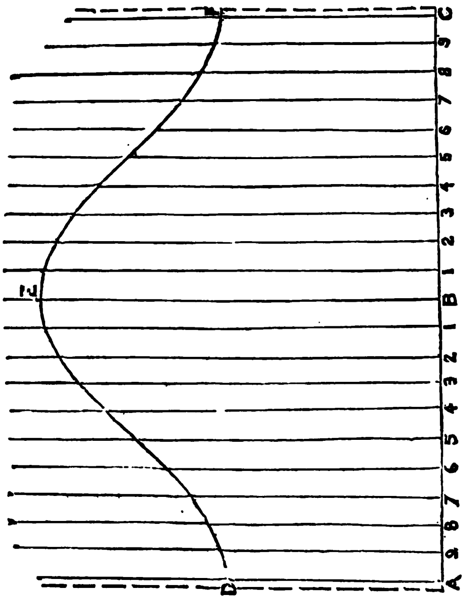
To describe an Elbow at Right Angles.

Fig. 61.



Let ABCD, fig. 61, be the given elbow; draw the line AB at right angles to BC; draw the line FC; describe the semicircle AGB; divide the semicircle into any number of equal parts; from the points draw lines parallel to BC, as 1, 2, 3, &c.

Fig. 62.



Set off the line ABC, fig. 62, equal in length to the circumference of the elbow AB; erect the perpendicular lines AD, BE and CF; set off on each side of BE the same number of equal distances, as in the semicircle AGB; from the points draw lines parallel to BE; make BE equal to BC; make AD and CF equal to AF; also, each of the parallel lines bearing the same figures as 11, 22, 33, &c.; then a line traced through the points will form the pattern.

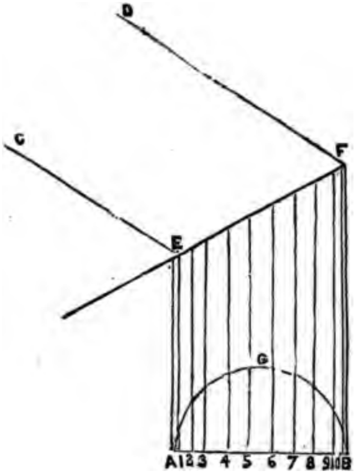
Edges to be allowed.

Patterns for Elbows may be described at any angle, by any of the Rules for cutting Elbow patterns; in laying out Elbow patterns let AB equal diameter of the Elbow, and BCD the angle.

ELBOWS.

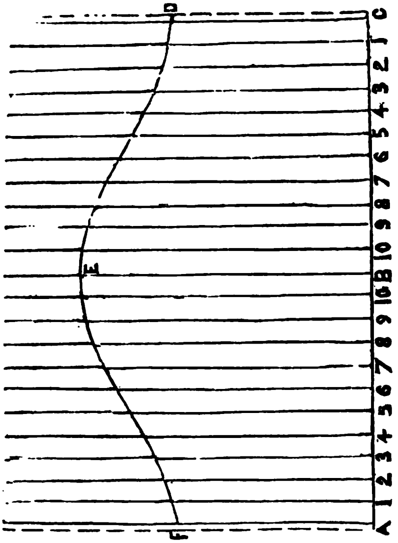
To describe an Elbow Pattern at any angle.

Fig. 63.



Let ABCD, fig. 63, be the given Elbow; draw the line AB at right angle to BF; draw the line EF; describe the semicircle AGB; divide the semicircle AGB into any number of equal parts; from the points draw lines parallel to BF, as 1, 2, 3, &c.

Fig. 64.



Set off the line ABC, fig. 64, equal in length to the circumference of the Elbow AB; erect the perpendicular lines AF, BE and CD; set off on each side of BE the same number of equal distances, as in the semicircle AGB; from the points draw lines parallel to BE, as 1, 1, 2, 2, 3, 3, &c.; make BE equal to BF; make AF and CD equal to AE; also, each of the parallel lines bearing the same figures as 1, 1, 2, 2, 3, 3, &c.

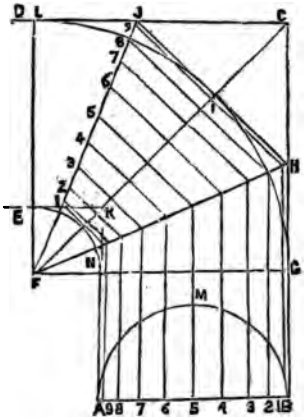
Then a line traced through the point will form the pattern.

Edges to be allowed.

ELBOWS.

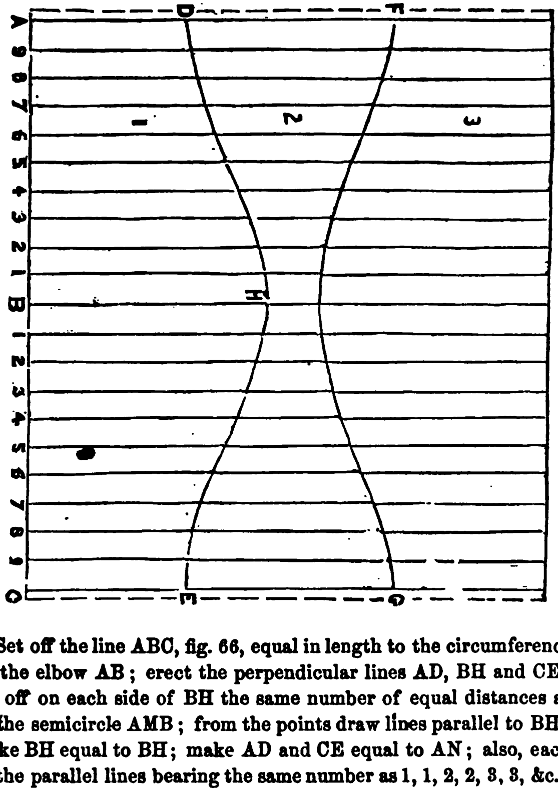
To describe a Pattern for an Elbow in Three Sections.

Fig. 65.



Let ABED, fig. 65, be the given elbow; draw the line FC; make FK equal to one-half the diameter of the elbow, with F as a centre; describe the arcs GL; divide the arc GL into four equal parts; draw the lines FH and FJ; also, the line JH; draw the line AB at right angles to BC; describe the semicircle AMB; divide the semicircle into any number of equal parts; from the points draw lines parallel to BH, as 1, 2, 3, &c.

Fig. 66.



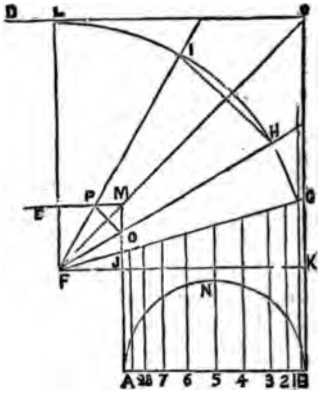
Set off the line ABC, fig. 66, equal in length to the circumference of the elbow AB; erect the perpendicular lines AD, BH and CE; set off on each side of BH the same number of equal distances as in the semicircle AMB; from the points draw lines parallel to BH; make BH equal to BH; make AD and CE equal to AN; also, each of the parallel lines bearing the same number as 1, 1, 2, 2, 3, 3, &c.; then a line traced through the points will form one of the sections; make DF and EG equal to HJ; then reverse section No. 1, and place D at G and E at F, and trace a line fron G to F, this will form section No. 2 and 3.

Edges to be allowed.

ELBOWS IN FOUR SECTIONS.

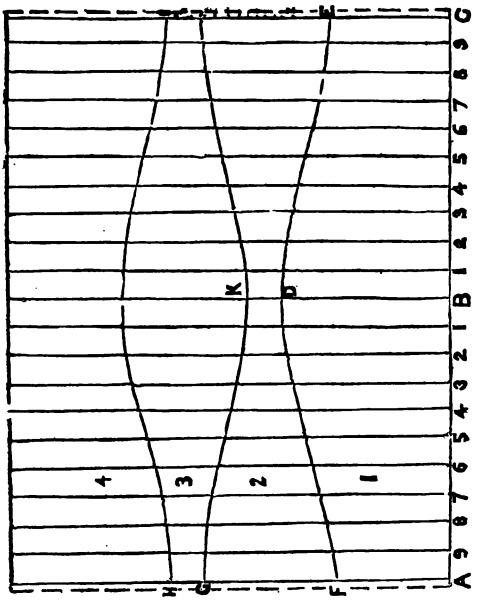
To describe a Pattern for an Elbow in Four Sections.

Fig. 67.



Let ABED, fig. 67, be the given elbow; draw the line FC; make FM equal in length to one-half the diameter of the elbow, with F as a centre; describe the arc KL; divide the arc KL into three equal parts; draw the lines FH and FI; also the line IH divide the section HK into two equal parts, and draw the line FG; draw the line AB at right angles to BC; describe the semicircle ANB; divide the semicircle into any number of equal parts, from the points draw lines parallel to BC, as 1, 2, 3, &c.

Fig. 68.



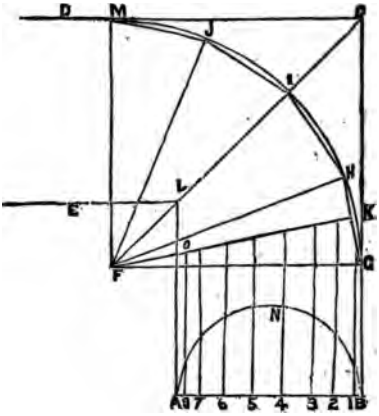
Set off the line ABC, fig. 68, equal in length to the circumference of elbow AB; erect the lines AF, BD and CE; set off on each side of the line BD the same number of equal distances as in the semicircle ANB; from the points draw lines parallel to BD as 1, 1, 2, 2, &c.; make BD equal to BG; make AF and CE equal to AJ; also, each of the parallel lines, bearing the same number as 1, 1, 2, 2, 3, 3, &c.; then a line traced through the points will form the first section; make FG and EJ equal to HI; reverse section No. 1; place E at G and F at J; trace a line from G to J; make GH and JI equal to PO, fig. 67, or to DK, fig, 68; take Sec. No. 1, place F at H and E at I, and trace a line from H to I, this forms Sec. No. 3 and 4.

Edges to be allowed.

ELBOWS.

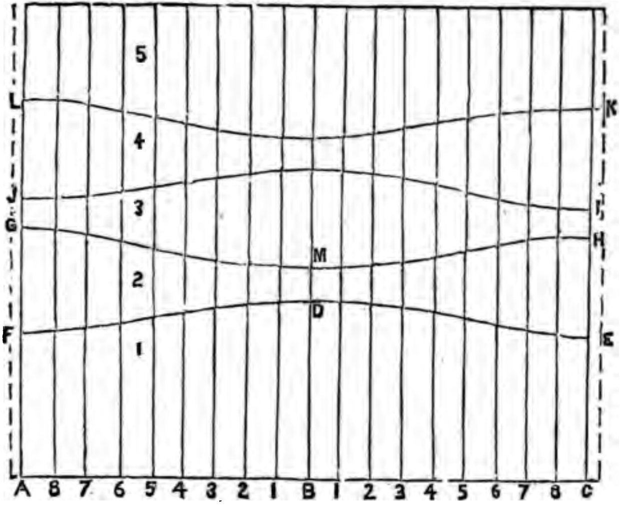
To describe a Pattern for an Elbow in Five Sections.

Fig. 69.



Let ABED, fig. 69, be the given elbow; draw the line FC; make FL equal in length to one-half the diameter of the elbow, with F as a centre; describe the arc GM; divide the arc GM into four equal parts, and draw the lines FJ and FH; also, the line IH; divide the section GH into two equal parts, and draw the line FK; draw the line AB at right angle to BC; describe the semicircle ANB; divide the semicircle into any number of equal parts; from the points draw lines parallel to BC, as 1, 2, 3, &c.

Fig. 70.



Set off the line ABC, fig. 70, equal in length to the circumference of the elbow AB; erect the perpendicular lines AL, BD and CK; set off on each side of BD the same number of equal distances as in the semicircle ANB; from the points draw lines parallel to BD as 1,1, 2,2, &c.; make BD equal to BK; make AF and CE equal to AO; also, each of the parallel lines bearing the same number, as 1,1, 2,2, 3,3 &c.; then a line traced through the points will form Sec. 1; make FG and EH equal to HI; reverse Sec. 1, place E at G and F at H, and trace a line from G to H; make GJ and HI equal DM in fig. 70; take Sec. 1 and place E at I and F at J, and trace a line from J to I; make JL and IK equal to HI; reverse Sec. 1, and place E at L and F at K, and trace a line from L to K, this completes Sec. No. 4 and 5; this completes the patterns; when elbows are to be of heavy iron and riveted, punch the holes for the rivets on the lines FE, GH, JI and LK, allowing f the lap each side on sections No. 2, 3, and 4.

ELBOWS.

To describe a Pattern for a Tapering Elbow.

Let AB and CD, fig. 71, equal large end of elbow, DHB the angle; make HF equal CG, and EF equal AB; make JK equal the small end of the elbow; draw the lines BK and AJ, continue the lines until they intersect at I; describe the semicircles AB and JK; divide the semicircles into the same number of equal parts; from the points draw lines, as 1, 2, 3, &c.

On any line, as AB, fig. 72, with the radii IK and IB; describe the arcs HI and CD; set off CAD equal in length to the circumference of the large end AB; draw the lines CB and DB; set off on each side of AB the same number of equal distances as in the semicircle AB; from the points draw lines cutting the centre at B; make AE equal to BL; make CF and DG equal to AM; also, each of the lines bearing the same figure as 1, 1, 2, 2, 3, 3, &c., then a line traced through the points will form the pattern.

Edges to be allowed.

Fig. 71.

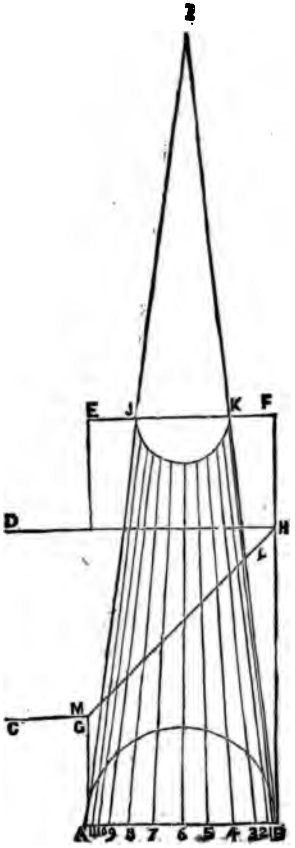
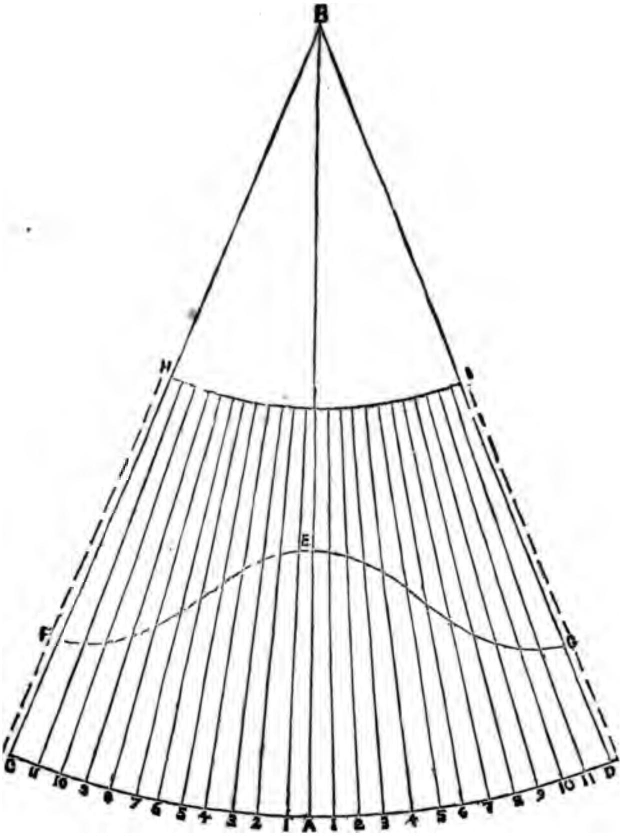


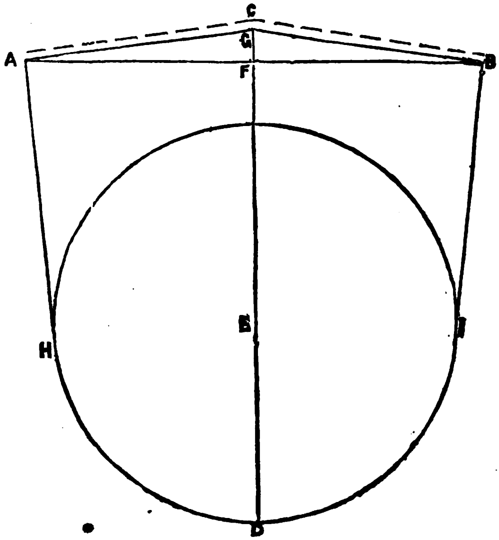
Fig. 72.



BOILER COVER.

To describe an Oval Boiler Cover.

Fig 78.

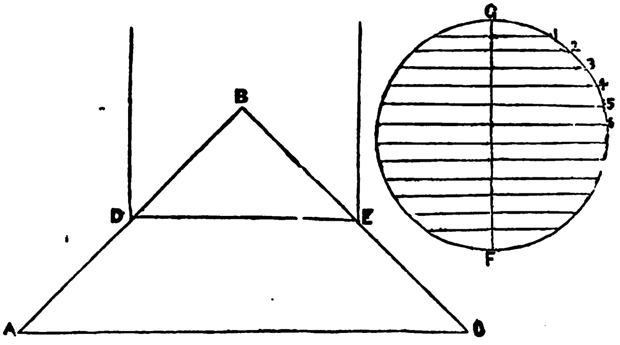


Erect the line DC; make FD equal to one-half the length of the boiler bottom before the edge is turned; describe the circle HDI one-eight of an inch larger in diameter than the breadth of the bottom; let FG be three-eights of an inch; then apply the corner of the square on the line AB, allowing the blade to cut the circle at I and the tongue at the point G; draw the lines GB, BH, also the lines GA, AH; allow one-eight of an inch for an edge, as shown by the dotted lines, the cover will be the same size a the bottom or pit.

FLANGE.

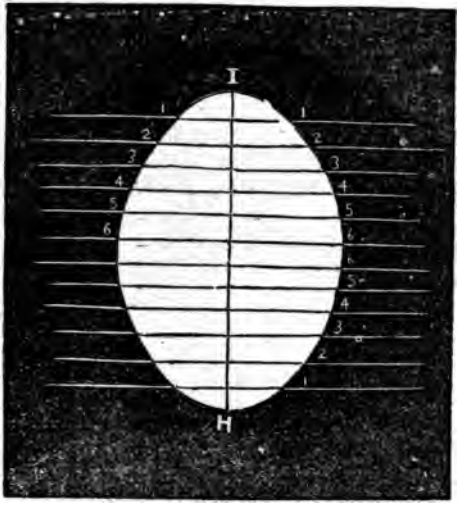
To describe a Pattern for a Flange for a Pipe that goes on the Roof of a Building, as fig. 59.

Fig 74. Fig. 75.



Let ABC, fig. 74, be the pitch of the roof; make DE equal to the diameter of the pipe; describe the circle FG; make FG the same in diameter as the pipe; draw the line FG; set off on the line FG any number of equal parts; from the points draw lines at right angle to FG as 1, 2, &c.

Fig. 76.

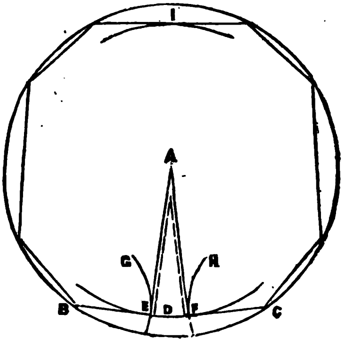


Set off the line HI, fig. 76, equal in length to DBE in fig. 74; set off on the line HI the same number of equal parts as in the line FG; from the points draw lines at right angle to HI; set off on each side of HI the same distance as on each side of the line FG in fig. 75, as 1, 1, 2, 2, &c.; a line traced through the points will form the piece to be cut out; when there is to be an edge turned up, it must be allowed inside of the line traced. The same rule is applied to describe a pattern for a flange for fig. 57; make HI, fig. 76, equal BF, fig. 57, then proceed the same as described above.

OCTAGON OR SQUARE TOP OR COVER.

To describe an Octagon or Square Top or Cover.

Fig. 77.

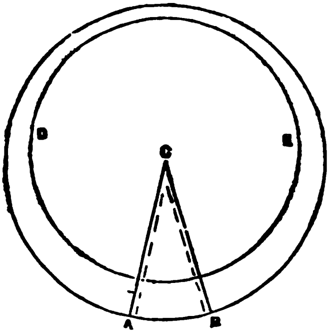


Describe a circle, three-quarters of an inch larger in diameter than a circle that will cut each corner of the article the top or cover is for; set off the squares from B to C; take one half of the largest square; and with B and C as centres, describe arcs G and H; then with A as centre, describe the arc cutting the square at I and the arc D; where the arcs GD and HD intersect, draw the lines AE and AF, also the lines BE and CF.

STEAMER COVER.

To describe a Steamer Cover.

Fig. 78.



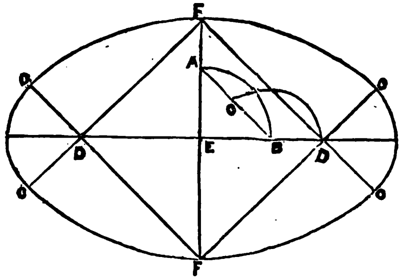
Describe a circle one inch larger in diameter than the hoop after the edge is laid off; lay the hoop on the plate, allowing an edge each side, as shown by the distance between the two circles and the dot on the line AC, the circle DE representing the hoop; take the distance from A to the dot on the line AC, and set off three times the distance on the outer circle, as from A to B; draw the lines AC and BC, cutting the centre at C.

Edges to be allowed.

OVAL.

To describe an Ellipse or Oval, having the Two Diameters given.

Fig. 79.

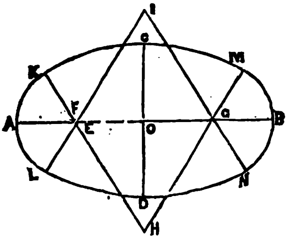


On the intersection of the two diameters as a centre, with a radius equal to one-half the difference of the two diameters, describe the arc AB, and from B as a centre, with half the chord ACB, describe the arc CD; from E as a centre with the distance ED cut the diameters at FF and DD; draw the lines FO, FO, FO, FO; then from F and F as centres, describe the arcs OO, and OO; also, from D and D as centres, describe the smaller arcs, OO and OO, which will complete the ellipse as required.

OVAL.

To draw an Ellipse with the Rule and Compasses, the transverse and conjugate Diameters being given; that is, the Length and Width.

Fig. 80.

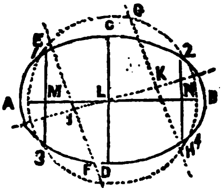


Let AB be the transvese or longest diameter; CD the conjugate or shortest diameter; and O the point of their intersection, that is the centre of the ellipse. Take the distance OC or OD; and, taking A as one point, mark that distance AE upon the line AO; divide OE into three equal parts, and take from AF, a distance EF, equal to one of those parts; make OG equal to OF with the radius FG, and F and G as centres; strike arcs which shall intersect each other in the points I and H; then draw the lines HFK, HGM, and IFL, IGN; with F as a centre, and the radius AF, describe the arc LAK; and, from G as a centre, with the same radius, describe the arc MBN; with the radius HC, and H as a centre, describe the arc KCM; and from the point I, with the radius ID, describe the arc LMD. The figure ACBD is an ellipse, formed of four arcs of circles.

ELLIPSE.

To find the Centre and the two Arcs of an Ellipse.

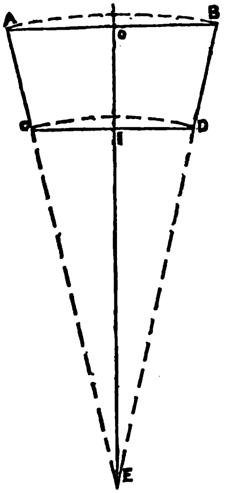
Fig. 81.



Let ABCD be an ellipse, it is required to find its centre; draw any two lines, as EF and GH, parallel and equal to each other; bisect these lines as in the points I and K, and bisect IK as in L from L, as a centre, draw a circle cutting the ellipse in four poins, 1,2,3,4, now L is the centre of the ellipse; but join the points 1, 3, and 2,4; and bisect these lines as in M and N; draw the line MN, and produce it to A and B, and it will be the transverse axis draw CD through L, and perpendicular to AB, and it will be the conjugate or shorter axis.

To find the Radius and Versed Sine for a given Frustrum of a Cone.

Fig. 82.



Multiply the slant height by one-half the diameter of the large end, and divide the product by one-half the difference of the two ends, and the quotent is the radius; the versed sine is found by multiplying the altitude by one-half the diameter of the large end; and dividing the product by one-half the difference of the two ends; then substract the quotent from the radius, and the remainder is the versed sine.

The diameter AB equal 12 inches; CD equal 8 inches; the slant height DB equal 10 inches, required the radius 10 × 6 = 60 ÷ 2 = 30 inches radius.

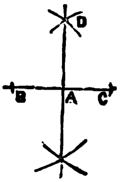
The diameter AB equal 12 inches; CD equal 8 inches; the altitude I O, 9.79 inches required versed sine, 9.79 × 6 = 58.74 ÷ 2 = 29.37; 30 — 29.37 = .63 versed sine.

Practical Geometry.

Geometry is the science which investigates and demonstrates the properties of lines on surfaces and solids; hence, **Practical Geometry** is the method of applying the rules of science to practical purposes.

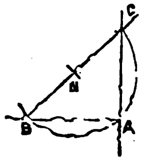
From any given point, in a straight line, to erect a perpendicular; or, to make a line at right angles with a given line.

On each side of the point A, from which the line is to be made, take equal distances, as AB, AC; and from B and D as centres, with any distance greater than BA, or CA, describe arcs cutting each other at D; then will the line AD be the perpendicular required.



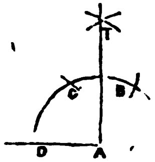
When a perpendicular is to be made at or near the end of a given line.

With any convenient radius, and with any distance from the given line AB, describe a portion of a circle, as BAC, cutting the given point in A; draw, through the centre of the circle N, the line BNC; and a line from the point A, cutting the intersection at C, is the perpendicular required.



To do the same otherwise

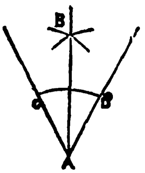
From the given point A, with any convenient radius, describe the arc DCB; from D, cut the arc in C, and from C, cut the arc in B; also, from C and B as centres, describe arcs cutting each other in T; then will the line AT be the perpendicular as required.



Note.—When the three sides of a triangle are in the proportion of 3, 4, and 5 equal parts, respectively, two of the sides form a right angle; and observe that in each of these or the preceding problems, the perpendiculars may be continued below the given lines, if necessarily required.

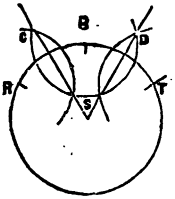
To bisect any given Angle.

From the point A as a centre, with any radius less than the extent of the angle, describe an arc as CD; and from C and D as centres, describe arcs cutting each other at B; then will the line AB bisect the angle as required.



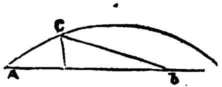
To find the centre of a Circle or Radius, that shall cut any three given points, not in a direct line.

From the middle point B as a centre, with any radius, as BC, BD, describe a portion of a circle, as CSD; and from R and T as centres, with an equal radius, cut the portion of the circle in CS and DS; draw lines through where the arcs cut each other; and the intersection of the lines at S is the centre of the circle as required.



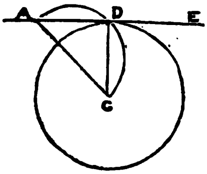
To find the length of any given arc of a Circle.

With the radius AC, equal to ¼th the length of the chord of the arc AB, and from A as a centre, cut the arc in C; also from B as a centre, with equal radius, cut the chord in B; draw the line CB; and twice the leng of the line is the length of the arc nearly.



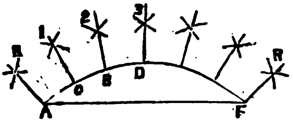
Through any given point, to draw a tangent to a circle.

Let the given point be at A; draw the line AC, on which describe the semicircle ADC; draw the line ADB, cutting the circumference in D, which is the tangent as required.



To draw from or to the circumference of a circle lines tending towards the centre, when the centre is inaccessible.

Divide the whole or any given portion of the circumference into the desired number of equal parts; then, with any radius less than the distance of two divisions, describe arcs cutting each other, as A1 B1, C2, D2, &c.; draw the lines C1, B2, D3, &c., which lead to the centre as required.

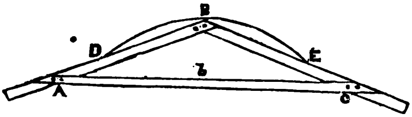


To draw the end lines.

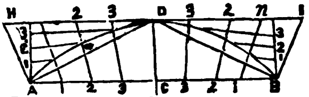
As AR, FR, from C describe the arc R, and with the radius CI, from A or F as centres, cut the former arcs at R, or R, and the lines AR, FR, will tend to the centre as required

To describe an arc, or segment of a circle of large radii.

Of any suitable material, construct a triangle, as ABC; take AB,BC, each equal in length to the chord of the arc DE, and height, twice that of the arc BB. At each end of the chord DE fix a pin, and at B, in the triangle, fix a tracer, (as a pencil,) move the triangle along the pins as guides; and the traces will describe the arc required.

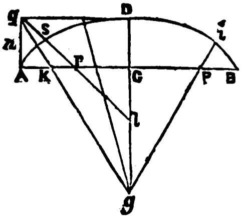


Or otherwise.

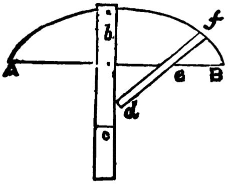


Draw the chord ACB; also, draw the line HDI, parallel with the chord, and equal to the height of the segment; bisect the chord in C, and erect the perpendicular CD; join AD, DB; draw AH perpendicular to AD, and BI perpendicular to BD, erect also the perpendiculars A *n*, B *n*; divide AB and HI into any number of equal parts; draw the lines 1, 1, 2, 2, 3, 3, &c.; likewise divide the lines A *n*, B *n*, each into half the number of equal parts; draw lines to D from each division in the lines A *n*, B *n*, and through where they intersect the former lines, describe a curve. which will be the arc or segment required.

To describe an Elliptic arch, the Width and Rise of Span been given.



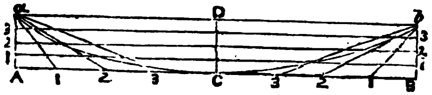
Bisect with a line at right angles the chord or span A B; erect the perpendicular A *q*, and draw the line *q* D equal and parallel to AC; bisect AC and A *q* in *r* and *n*; make C *l* equal to CD, and draw the line *l r q*; draw also the line *n s* D; bisect *s* D with a line at right angles, and meeting the line CD in *g*; draw the line *g q*, make CP equal to C *k*, and draw the line *g* P *i*; then from *g* as a centre, with the radius *g* D, describe the arc *s* D *i*; and from *k* and P as centres, with the radius A *k*, describe the arcs A *s* and B *i*, which completes the arch as required. *Or*,



Bisect the chord AB, and fix at right angles any straight guide, as *b c*; prepare, of any suitable material, a rod or staff, equal to half the chord's length, as *d e f*; from the end of the staff, equal to the height of the arch, fix a pin *e*, and at the extremity a tracer *f*; move the staff, keeping its end to the guide and the fixed pin to the chord; and the tracer will describe one-half the arc required.

To describe a Parabola, the dimensions been given.

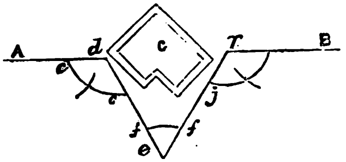
Let AB equal the length, and CD the breadth of the required parabola; divide CA, CB into any number of equal parts; also,



divide the perpendiculars A *a* and B *b* into the same number of equal parts; then from *a* and *b* draw lines meeting each division on the line ACB, and a curve line drawn through each intersection will form the parabola required.

To obtain by measurement the length of any direct line, though intercepted by some material object.

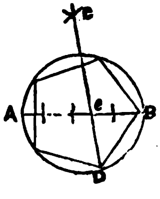
Suppose the distance between A and B is required, but the right line is intercepted by the object C. On the point *d*, with



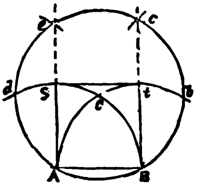
any convenient radius, describe the arc *c c*, make the arc twice the radius in length, through which draw the line *d c e*, and on *e* describe another arc equal in length to once the radius, as *e f f;* draw the line *e f r* equal to *e f d;* on *r* describe the arc *j j*, in length twice the radius; continue the line through *r j*, which will be a right line, and *d e*, or *e r*, equal the distance between *d r*, by which the distance between A and B is obtained as required.

To inscribe any Regular Polygon in a given circle.

Divide any diameter, as AB, into so many equal parts as the polygon is required to have sides; from A and B as centres, with a radius equal to the diameter, describe arcs cutting each other in C; draw the line CD through the second point of division on the diameter *e*, and the line DB is one side of the polygon required.

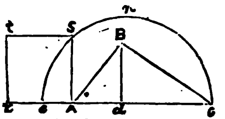


To construct a Square upon a given right line.



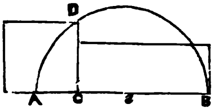
From A and B as centres, with the radius AB, describe the arcs *Acb*,B*cd*, and from *c*, with an equal radius, describe the circle or portion of a circle *cd*, AB, *bc;* from *bd* cut the circle at *e* and *c;* draw the lines A*e*,B*c*, also the line *st*, which completes the square as required.

To form a Square equal in area to a given triangle.



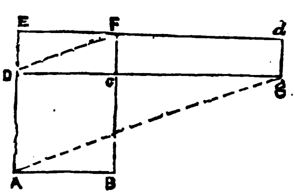
Let ABC be the given triangle; let fall the perpendicular B*d*, and make A*e* half the height *d*B; bisect *e*C, and describe the semicircle *en*C; erect the perpendicular A*s*, or side of the square, then A *s t x* is the square of equal area as required.

To form a Square equal in area to a given rectangle.



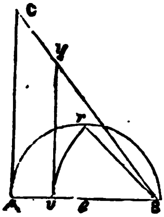
Let the line AB equal the length and breadth of the given rectangle; bisect the line in *e*, and describe the semicircle ADB; then from A with the breadth, or from B with the length, of the rectangle, cut the line AB at C, and erect the perpendicular CD, meeting the curve at D, and CD equal a side of the square required.

To find the Length for a rectangle whose area shall be equal to that of a given Square, the Breadth of the rectangle being also given.



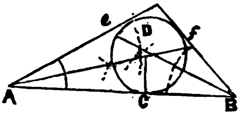
Let ABCD be the given square, and DE the given breadth of rectangle; continue the line BC to F, and draw the line DF; also, continue the line DC to *g*, and draw the line A*g* parallel to DF; from the intersection of the lines at *g*, draw the line *gd* parallel to DE, and E*d* parallel to D*g;* then ED*dg* is the rectangle as required.

To bisect any given Triangle.



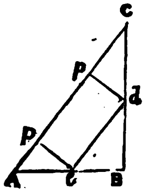
Supose ABC the given triangle; bisect one of its sides, as AB in *e*, from which describe the semicircle A*r*B; bisect the same in *r*, and from B, with the distance B*r*, cut the diameter AB in *v*; draw the line *vy* parallel to AC, which will bisect the triangle as required.

To describe a Circle of greatest diameter in a given triangle.



Bisect the angles A and B, and draw the intersecting lines AD, BD, cutting each other in D; then from D as centre, with the distance or radii DC, describe the circle C*ef*, as required.

To form a Rectangle of greatest surface in a given triangle.



Let ABC be the given triangle; bisect any two of its sides, as AB, BC, in *e* and *d*; draw the line *ed*; also at right angles with the line *ed*, draw the lines *ep*,*dp*, and *eppd* is the rectangle required.

DECIMAL EQUIVALENTS TO FRACTIONAL PARTS OF LINEAL MEASUREMENT.

One Inch the Integer or Whole Number.

.96875	are equal to	$\frac{7}{8}$ & $\frac{3}{32}$	.46875	“	$\frac{3}{8}$ & $\frac{3}{32}$
.9375	“	$\frac{7}{8}$ & $\frac{1}{16}$	.4375	“	$\frac{3}{8}$ & $\frac{1}{16}$
.90625	“	$\frac{7}{8}$ & $\frac{1}{32}$	.40625	“	$\frac{3}{8}$ & $\frac{1}{32}$
.875	“	$\frac{7}{8}$	.375	“	$\frac{3}{8}$
.84375	“	$\frac{3}{4}$ & $\frac{3}{32}$	.34375	“	$\frac{1}{4}$ & $\frac{3}{32}$
.8125	“	$\frac{3}{4}$ & $\frac{1}{16}$	.3125	“	$\frac{1}{4}$ & $\frac{1}{16}$
.78125	“	$\frac{3}{4}$ & $\frac{1}{32}$	.28125	“	$\frac{1}{4}$ & $\frac{1}{32}$
.75	“	$\frac{3}{4}$	.25	“	$\frac{1}{4}$
.71875	“	$\frac{5}{8}$ & $\frac{3}{32}$	.21875	“	$\frac{1}{8}$ & $\frac{3}{32}$
.6875	“	$\frac{5}{8}$ & $\frac{1}{16}$	.1875	“	$\frac{1}{8}$ & $\frac{1}{16}$
.65625	“	$\frac{5}{8}$ & $\frac{1}{32}$	.15625	“	$\frac{1}{8}$ & $\frac{1}{32}$
.625	“	$\frac{5}{8}$	.125	“	$\frac{1}{8}$
.59375	“	$\frac{1}{2}$ & $\frac{3}{32}$	.09375	“	$\frac{3}{32}$
.5625	“	$\frac{1}{2}$ & $\frac{1}{16}$	.0625	“	$\frac{1}{16}$
.53125	“	$\frac{1}{2}$ & $\frac{1}{32}$	.03125	“	$\frac{1}{32}$
.5	“	$\frac{1}{2}$			

One Foot or 12 Inches the Integer.

.9166	are equal to	11 inches.	.1666	are equal to	2 inches.
.8333	“	10 “	.0833	“	1 “
.75	“	9 “	.07291	“	$\frac{7}{8}$ “
.6666	“	8 “	.0625	“	$\frac{3}{4}$ “
.5833	“	7 “	.05208	“	$\frac{5}{8}$ “
.5	“	6 “	.04166	“	$\frac{1}{2}$ “
.4166	“	5 “	.03125	“	$\frac{3}{8}$ “
.3333	“	4 “	.02083	“	$\frac{1}{4}$ “
.25	“	3 “	.01041	“	$\frac{1}{8}$ “

DEFINITIONS OF ARITHMETICAL SIGNS USED IN THE FOLLOWING CALCULATIONS.

$=$ Sign of Equality, and signifies as $4 + 6 = 10$.
$+$ “ Addition, “ as $6 + 6 = 12$, the Sum.
$-$ “ Substraction, “ as $6 - 2 = 4$, “ Remainder.
$\times$ “ Multiplication, “ as $8 \times 3 = 24$, “ Product.
$\div$ “ Division, “ as $24 \div 3 = 8$ or $\frac{24}{3} = 8$.
$\surd$ “ Square Root, “ Evolution or Extraction of Square Root.
6^2 “ to be Squared, “ thus $8^2 = 64$ Involution, or
7^3 “ to be Cubed, “ thus $3^3 = 27$ the Raising of Powers.

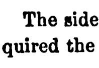
Mensuration of Surfaces.

Mensuration is that branch of Mathematics which is employed in ascertaining the extension, solidities and capacities of bodies capable of being measured.

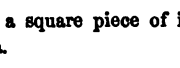
MENSURATION OF SURFACES.

To Measure or Ascertain the quantity of Surface in any Right lined figure, whose Sides are Parallel to each other, as figs. 1, 2 *and* 3.

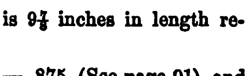
Square.
1.



Rectangle.
2.



Rhomboid.
3.



Rule.—Multiply the length by the breadth or perpendicular height and the product will be the area or superficial contents.

Application of the Rule to Practical purposes.

The sides of a square piece of iron is 9⅞ inches in length required the area.

Decimal equivalent to the fraction ⅞ = .875. (See page 91), and 9.875 × 9.875 = 97.5, &c., square inches the area.

2. The length of a Roof is 60 ft. 4 in., and its width 25 ft. 3 in. required the area of the Roof.

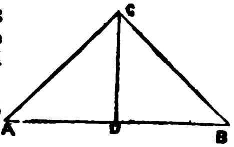
4 iuches = 333 and 3 inches = .25, (See table of equivalents,) hence, 60.333 × 25.25 = 1523.4 Square feet the area.

TRIANGLES.

To find the Area of a Triangle when the base and perpendicular are given, fig. 3.

Rule.—Multiply the base by the perpendicular height, and half the product is the area.

Fig. 4.



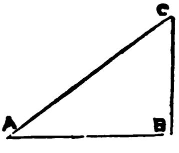
The base of the triangle, fig. 4, ADB is 3 feet 6 inches in length, and the height, DC, 1 foot 9 inches required the area.

6 inches = .5, and 9 inches = 75;

hence $\frac{3.5\times1.75}{2}$=3.0625 Square feet the area.

Any two sides of a Right Angled Triangle being given to find the third.

Fig. 5.



When the base and perpendiculars are given to find the hypothenuse.

Add the square of the base to the square of the perpendicular, and the square root of the sum will be the hypothenuse.

The base of the triangle, fig. 5, AB is 4 feet, and the perpendicular BC 3 feet, then $4^2 + 3^2 = 25$, $\sqrt{25} = 5$ feet the hypothenuse.

When the Hypothenuse and Base are given, to find the Perpendicular.

From the Square of the hypothenuse, subtract the Square of the base, and the Square of the remainder will be the perpendicular.

The hypothenuse of the triangle, fig. 5, AC, is 5 feet, and the base, AB, 4 feet; then $5^2-4^2 = 9$, and $\sqrt{9} = 3$ the perpendicular.

When the Hypothenuse and the Perpendicular are given to find the base.

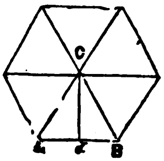
From the Square of the hypothenuse subtract the square of the perpendicular and the square root of the remainder will be the base.

9

OF POLYGONS.

To find the Area of a Regular Polygon.

Fig. 6.



Rule.—Multiply the length of a side by half the distance from the side to the centre, and that product by the number of sides; the last product will be the area of the figure.

Example.—The side AB of a regular hexagon is 12 inches, and the distance therefrom to the centre of the figure, *d c*, is 10 inches; required the area of the hexagon.

$$\frac{10}{2} \times 12 \times 6 = 360 \text{ sq. in.} = 2\tfrac{1}{2} \text{ sq. feet.} \quad \textit{Ans.}$$

To find the Area of a Regular Polygon, when the Side only is given.

Rule.—Multiply the square of the side by the multiplier opposit to the name of the Polygon in the 9th column of the following Table, and the product will be the area.

Table *of angles relative to the construction of Regular Polygons with the aid of the Sector, and of co-efficients to facilitate their construction without it; also, of co-efficients to aid in finding the area of the figure, the side only being given.*

Names.	No. of sides	Angle at centre.	Angle at circum.	Perpn'n. side being 1.	Length of side rad's being 1.	Radius of circl',side being 1.	Rad.' of cir.perp being 1.	Area side being 1.
Triangle,	3	120°	60°	0.28868	1.782	.5773	2.	0.433012
Square,	4	90	90	0.5	1.414	.7071	1.414	1.
Pentagon,	5	72	108	0.6882	1.175	.8506	3.238	1.720477
Hexagon,	6	60	120	0.866	1.	1.	1.156	2.598076
Heptagon,	7	$51\frac{3}{7}$	$128\frac{4}{7}$	1.0382	.8672	1.152	1.11	3.633912
Octagon,	8	45	135	1.2071	.7654	1.3065	1.08	4.828427
Nonagon,	9	40	140	1.3737	.684	1.4619	1.06	6.181824
Decagon,	10	36	144	1.5388	.618	1.618	1.05	7.694208
Undecagon,	11	$32\frac{8}{11}$	$147\frac{3}{11}$	1.7028	.5634	1.7747	1.04	9.36564
Dodecagon,	12	30	150	1.866	.5176	1.9318	1.037	11.196152

Note—"Angle at centre" means the angle of radii, passing from the centre to the circumference, or corners of the figure. "Angle at circumference" means the angle which any two adjoining sides make with each other.

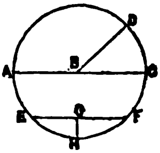
THE CIRCLE AND ITS SECTIONS.

Observations and Definitions.

1. The Circle contains a greater area than any other plain figure bounded by the same perimeter or outline.

2. The areas of Circles are to each other as the squares of their diameters; any Circle twice the diameter of another contains four times the area of the other.

Fig. 7.



3. The radius of a circle is a Straight line drawn from the centre to the circumference, as BD, fig. 7.

4. The diameter of a circle is a Straight line drawn through the centre and terminated both ways at the circumference, as ABC.

5. A chord is a Straight line joining any two points of the circumference, as EF.

6. The Versed sine is a Straight line joining the chord, and the circumference as GH.

7. An arc is any part of the circumference, as AEH.

8. A Semicircle is half the circumference cut off by a diameter, as AHC.

9. A Segment is any portion of a circle cut off by a chord, as EHF.

10. A Sector is a part of a circle cut off by two radii, as CBD.

General Rules in Relation to the Circle.

1. Multiply the diameter by 3.1416 the product is the Circumference.

2. Multiply the circumference by 31831, the product is the diameter.

3. Multiply the square of the diameter by .7854, and the product is the area.

4. Multiply the square root of the area by 1.12837, the product is the diameter.

5. Multiply the diameter by .8862, the product is the side of a Square of equal area.

6. Multiply the side of a square by 1.128, the product is the diameter of a circle of equal area.

Application of the Rules to Practical Purposes.

1. The diameter of a circle being 5 ft. 6 inches, required it circumference.

$$5.5 \times 3\ 1416 = 17.27880$$ feet the circumference.

2. A straight line, or the circumference of a circle being 17.27880 feet required the circle's diameter corresponding thereto.

$$17.27880 + .31831 = 5.5000148280$$ feet diameter.

3. The diameter of a circle is 9⅜ inches; what is its area in square inches?

$$9.375^2 = 87.89, \&c. \times .7854 = 69.029, \&c.,$$ inches the area.

4. What must the diameter of a circle be to contain an area equal to 69.029296875 square inches.

$$\sqrt{69.02929}, \&c., = 8.3091 \times 1.12837 = 9.375, \&c.,$$ or 9⅜ inches the diameter.

5. The diameter of a circle is 15½ inches; what must each side of a square be, to be equal in area to the given circle?

$$15.5 \times .8862 = 13.73, \&c.,$$ inches length of side.

6. Each side of a square is 13.736 inches in length, what must the diameter of a circle be to contain an area equal to the given square.

$$13.736 \times 1.128 = 15.49\ \&c,$$ or 15½ inches the diameter.

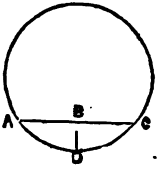
Any chord and versed sine of a circle being given to find the diameter.

Rule.—Divide the sum of the squares of the chord and versed sine by the versed sine, the quotent is the diameter of corresponding circle.

7. The chord of a circle AC, fig. 8, equal 8 feet, and the versed sine, BD equal 1½ feet, required the circles diameter.

$$8^2 + 1.5^2 = 66.25 \div 1.5 = 44.16$$ feet the diameter.

Fig. 8.



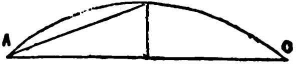
8. In the curve of a railway, I stretched a line 80 feet in length, and the distance from the line to the curve I found to be 9 inches, required the circles diameter.

$80^2 + .75^2 = 640.5625 \div 2 = 320.28$, &c., feet the diameter.

To find the Length of any arc of a circle.

RULE.—From eight times the chord of half the arc, subtract the chord of the whole arc, and one-third of the remainder will be the length nearly.

Fig. 9.



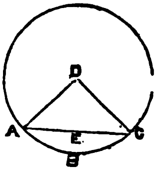
Required the length of the arc ABC, fig. 9. the chord AB of half the arc being 8½ ft., and chord AC of the whole arc 16 ft. 8 inches.

$$8.5 \times 8 = 68.0 \text{ and } 68.0 - 16.666 = \frac{41.334}{3} = 13.778 \text{ c. feet}$$

the length of the arc.

To find the area of the sector of a circle.

Fig. 10.



RULE.—Multiply the length of the arc by half the length of the radius.

The length of the arc ABC, fig. 10, equals 9½ inches, and the radii DA, DC equal each 7 inches required the area

$9.5 \times 3.5 = 33.25$ inches the area.

To find the area of a Segment of a circle.

RULE.—Find the area of a sector whose arc is equal to that of the given segment, and if it be less then a semicircle subtract the area of the triangle formed by the chord of the segment and radii of its extremities; but if more than a semicircle add the area of the triangle to the area of the sector and the remainder or sum is the area of the segment.

Thus suppose the area of the segment ABC, E fig. 10, is required and that the length of the arc ABC equals 19½ ft., DA and DC each equal 14 ft., and the chord AC equal 16 ft., 8 inches; also the perpendicular ED equal 7½ feet.

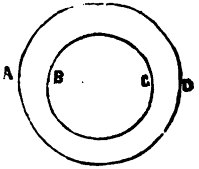
$19.5 \times 7 = 136.5$ feet the area of the sector, $\frac{16.666 \times 7.5}{2} =$ 62.49 feet the area of the triangle, $136.5 - 62.49 - 74.01$ feet the area of the segment.

5

To find the area of the space contained between two Concentric Circles or the area of a Circular Ring.

RULE.—1 Multiply the sum of the inside and out side diameters by their difference and by .7854 the product is the area.

Fig. 11.



RULE 2.—The difference of the areas of the two circles will be the area of the Ring on space.

Suppose the external circle AD, fig. 11, equal 4 ft., and the internal circle BC 2½ ft., required the area of the space contained between them or area of a Ring.

4 + 2.5 = 6.5 and 4 — 2.5 = 1.5 hence, 6.5 × 1.5 × .7854 = 7.65 ft., the area ; or,

The area of 4 ft., is 12.566 ; the area of 2.5 is 4.9081. (See table of areas of circles.)

12.566 — 4.9081 = 7.6579 the area.

To find the area of Ellipse or Oval.

RULE.—Multiply the diameter together and their product by .7854.

An oval is 20 inches by 15 inches what are its superficial contents 20 × 15 × .7854 = 235.62 inches the area.

To find the circumference of an Ellipse or Oval.

RULE.—Multiply half the sum of the two diameters by 3.1416, the product will be the circumference.

EXAMPLE.—An oval is 20 inches by 15 inches what is its circumference.

$$\frac{20 + 15}{2} = 17.5 \times 3.1416 = 54.978 \text{ inches the circumference.}$$

OF CYLINDERS.

To find the Convex Surface of a Cylinder.

RULE.—Multiply the circumference by the height or length the product will be the surface.

EXAMPLE.—The circumference of a cylinders is 6 ft., 4 inches and its length 15 ft., required the convex surface,

$$6.333 \times 15 = 94.995 \text{ square feet the surface.}$$

OF CONES OR PYRAMIDS

To find the Convex Surface of a Right Cone or Pyramid

RULE.—Multiply the perimeter circumference of the base by the slant height, and half the product is the slant surface if the surface of the entire figure is required, and the area of the base to the convex surface.

EXAMPLE.—The base of a Cone, fig. 13, is 5 ft., diameter and the slant height is 7 feet, what is the convex surface ?

$$5 \times 3.1416 = 15.70 \text{ circumference of the base and } \frac{15.70 \times 7}{2} = 54.95$$

square feet the convex surface.

To find the Convex Surface of a Frustrum of a Cone or Pyramid.

RULE.—Multiply the sum of the circumference of the two ends by the slant height, and half the product will be the slant surface.

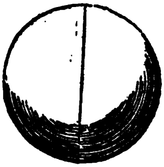
The diameter of the top of a Frustom of a Cone, fig. 14, is 3 ft., the base 5 ft., the slant height 7 ft. 3 inches, required the slant surface.

$$9.42 + 15.7 = \frac{25.12 \times 7.25}{} = 91.06 \text{ square ft., the slant surface.}$$

OF SPHERES.

To find the Convex Surface of a Sphere or Globe, fig. 12.

Fig. 12.



RULE.—Multiply the diameter of the Sphere by its circumference, and the product is its surface; or,

Multiply the square of the diameter by 3.1416, the product is its surface.

What is the Convex Surface of a globe, 6½ ft., in diameter?

6.5 × 3.1416 × 6.5 = 132.73 square feet; or, $6.5^2 = 42.25 \times 3.1416 = 132.73$ square feet the Convex surface.

MENSURATION OF SOLIDS AND CAPACITIES OF BODIES.

To find the Solidity or capacity of any figure in the Cubical Form.

RULE.—Multiply the length of any one side by its breadth and by the depth or distance to its opposite side, the product is the solidity or capacity in equal terms of measurement.

EXAMPLE.—The side of a cube is 20 inches, what is the solidity? 20 × 20 × 20 = 8000 cubic inches; or, 4.6296 cubic feet nearly.

A Rectangular tank is in length 6 feet, in breadth 4½ feet, and in depth 3 feet, required its capacity in cubic feet; also its capacity in U. S. Standard gallons.

6 × 4.5 × 3 = 81 cubic feet, 81 × 1728 = 139968 ÷ 231 = 605.92 gallons.

OF CYLINDERS.

To find the Solidity of Cylinders.

Rule.—Multiply the area of the base by the height, and the product is the solidity.

Example.—The base of a cylinder is 18 inches, and the height is 40 inches—what is the solidity?

$$18^2 \times .7854 \times 40 = 10178.7840 \text{ cubic inches.}$$

To find the Contents in Gallons of Cylindrical Vessels.

Rule.—Take the dimensions in inches and decimal parts of an inch. Square the diameter, multiply it by the height, then multiply the product by .0034 for Wine gallons, or by .002785 for Beer gallons.

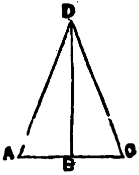
Example.—How many U. S. Gallons will a Cylinder contain, whose diameter is 18 inches and length 30 Inches.

$$18^2 \times 30 = 9720 \times .0034 = 33.04, \text{\&c., gallons.}$$

OF CONES AND PYRAMIDS.

To find the Solidity of a Cone or a Pyramid.

Fig. 13.



Rule.—Multiply the area of the Base by the perpendicular height, and ⅓ the product will be the Solidity.

Example.—The base of a cone, fig. 13, is 2 ¼ ft., and the height is 3 ¾ feet, what is the Solidity.

$$\frac{2.25 \times .7854 \times 3.75}{3} = 497 \text{ cubic feet the Solidity.}$$

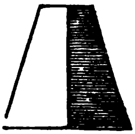
To find the Solidity of the Frustrum of a Cone.

Rule.—To the Product of the diameters ef the ends, add ⅓ the square of the difference of the diameters; multiply the sum by .7854 and the product will be the mean area between the ends, which multiplied by the perpendicular's height of the Frustrom, gives the Solidity.

Example.—The diameter of the large end of a Frustrom of a Cone, fig. 14, is 10 feet, that of the smaller end is 6 feet, and the perpendicular height 12 feet, what is the Solidity?

$10 - 6 = 4^2 = 16 \div 3 = 5.333$ sq. of difference of ends; and $10 \times 6 + 5.333 = 65.333 \times .7854 \times 12 = 615.75$ cubic feet the Solidity.

Fig. 14.



To find the Contents in U. S. Standard Gallons of the Frustrum of a Cone.

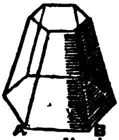
Rule.—To the product of the diameters in inches, and decimal parts of an inch of the ends, add ⅓ the square of the difference of the diameters Multiply the sum by the perpendicular height in inches and decimal parts of an inch, and multiply that product by .0034 for Wine gallons, and by .002785 for Beer gallons.

Example.—The diameter of the large end of a Frustrum of a Cone, fig. 14, is 8 feet, that of the smaller end is 4 feet, and the perpendicular height 10 feet—what is the Contents in U. S. Standard gallons?

$$96 - 48 = 48^2 = 2304 \div 3 - 768;\ 96 \times 48 + 768 = 5376 \times 120 \times .0034 = 2193.4 \text{ gallons.}$$

To find the Solidity of the Frustrum of a Pyramid.

Fig. 15.



Rule.—Add to the areas of the two ends of the Frustrum, the square root of their product, and this sum multiplied by $\frac{1}{3}$ of the perpendicular height will give the Solidity.

Example.—What is the Solidity of a hexagonal pyramid, fig. 15, a side of the large end AB, being 12 feet, and one of the smaller ends 6 feet, and the perpendicular height 8 feet?

$$374.122 + 93.53 = \sqrt{34991.63} = 590.811\ \ 374.122 + 93.53 \div$$

$$590.811 = \frac{1058.\ .463 \times 8}{3} = 2822.568 \text{ Cubic ft. the Solidity.}$$

To find the Solidity of a Sphere.

Rule.—Multiply the Cube of the diameter by .5236 and the product is the Solidity.

Example.—What is the Solidity of a Sphere, fig. 15, the diameter being 20 inches?

$20^3 = 8000 \times .5236 = 4188.8$ Cubic inches the Solidity.

Tables of Weights, &c.

Weight of Square Rolled Iron, from 1-4 *Inch to* 12 *Inches, and* 1 *Foot in Length.*

Size in Inches.	Weight in Pounds	Size in Inches.	Weight in Pounds	Size in Inches.	Weight in Pounds.
¼	0.2	3¼	35.7	6½	142.8
⅜	0.5	3⅜	38.5	6¾	154.0
½	0.8	3½	41.4	7	165.6
⅝	1.3	3⅝	44.4	7¼	177.7
¾	1.9	3¾	47.5	7½	190.1
⅞	2.6	3⅞	50.8	7¾	203.0
1	3.4	4	54.1	8	216.3
1⅛	4 3	4⅛	57.5	8¼	230.1
1¼	5.3	4¼	61.1	8½	244.2
1⅜	6.4	4⅜	64.7	8¾	258.8
1½	7.6	4½	68.4	9	273.8
1⅝	8.9	4⅝	72.3	9¼	289.2
1¾	10.4	4¾	76.3	9½	305.1
1⅞	11.9	4⅞	80.3	9¾	321.3
2	13.5	5	84.5	10	337.9
2⅛	15.3	5⅛	88.8	10¼	355.1
2¼	17.1	5¼	93.2	10½	372.7
2⅜	19.1	5⅜	97.7	10¾	390.6
2½	21.1	5½	102.2	11	409.0
2⅝	23.3	5⅝	107.0	11¼	427.8
2¾	25.6	5¾	111.8	11½	447.0
2⅞	27.9	5⅞	116.7	11¾	466.7
3	30.4	6	121.7	12	486.7
3⅛	33.0	6¼	132.0		

Weight of Flat Rolled Iron from 1-8 × 1-2 *Inch to* 1 × 6 *Inches.*

Thick	Width.	Weight in Pounds.	Thick:	Width:	Weight in Pounds.	Thick:	Width:	Weight in Pounds:
⅛	½	0.211	⅜	4	5.1	⅝	3¼	6.9
⅛	⅝	0.264	⅜	4¼	5.4	⅝	3½	7.4
⅛	¾	0.316	⅜	4½	5.7	⅝	3¾	7.9
⅛	⅞	0.369	⅜	4¾	6.0	⅝	4	8.4
⅛	1	0.422	⅜	5	6.3	⅝	4¼	9.0
⅛	1⅛	0.475	⅜	5¼	6.7	⅝	4½	9.5
¼	1	0.8	⅜	5½	7.0	⅝	4¾	10.0
¼	1¼	1.1	⅜	5¾	7.3	⅝	5	10.6
¼	1½	1.3	⅜	6	7.6	⅝	5¼	11.1
¼	1¾	1.5	½	1	1.7	⅝	5½	11.6
¼	2	1.7	½	1¼	2.1	⅝	5¾	12.1
¼	2¼	1.9	½	1½	2.5	⅝	6	12.7
¼	2½	2.1	½	1¾	3.0	¾	1	2.5
¼	2¾	2.3	½	2	3.4	¾	1¼	3.2
¼	3	2.5	½	2¼	3.8	¾	1½	3.8
¼	3¼	2.7	½	2½	4.2	¾	1¾	4.4
¼	3½	3.0	½	2¾	4.6	¾	2	5.1
¼	3¾	3.2	½	3	5.1	¾	2¼	5.7
¼	4	3.4	½	3¼	5.5	¾	2½	6.3
¼	4¼	3.6	½	3½	5.9	¾	2¾	7 0
¼	4½	3.8	½	3¾	6.3	¾	3	7.6
¼	4¾	4.0	½	4	6.8	¾	3¼	8.2
¼	5	4.2	½	4¼	7.2	¾	3½	8.9
¼	5¼	4.4	½	4½	7.6	¾	3¾	9.5
¼	5½	4.6	½	4¾	8.0	¾	4	10.1
¼	5¾	4.9	½	5	8.4	¾	4¼	10.8
¼	6	5.1	½	5¼	8.9	¾	4½	11.4
⅜	1	1.3	½	5½	9.3	¾	4¾	12.0
⅜	1¼	1.6	½	5¾	9.7	¾	5	12.7
⅜	1½	1.9	½	6	10 1	¾	5¼	13.3
⅜	1¾	2.2	⅝	1	2.1	¾	5½	13.9
⅜	2	2.5	⅝	1¼	2.6	¾	5¾	14.6
⅜	2¼	2.9	⅝	1½	3.2	¾	6	15.2
⅜	2½	3.2	⅝	1¾	3.7	1	1½	5.1
⅜	2¾	3.5	⅝	2	4.2	1	2	6.8
⅜	3	3.8	⅝	2¼	4.8	1	3	10.1
⅜	3¼	4.1	⅝	2½	5.3	1	4	13.5
⅜	3½	4.4	⅝	2¾	5.8	1	5	16.9
⅜	3¾	4.8	⅝	3	6.3	1	6	20.2

Weight of Round Rolled Iron from 1-4 *Inch to* 12 *Inches in Diameter, and* 1 *foot in Length.*

Diameter in Inches.	Weight in Pounds.	Diameter in Inches.	Weight in Pounds.
1-4	0.2	4 3-4	60.0
3-8	0.4	4 7-8	63.1
1-2	0.7	5	66.8
5-8	1.0	5 1-8	69.7
3-4	1.5	5 1-4	73.2
7-8	2.0	5 3-8	76.7
1	2.7	5 1-2	80.3
1 1-8	3.4	5 5-8	84.0
1 1-4	4.2	5 3-4	87.8
1 3-8	5.0	5 7-8	91.6
1 1-2	6.0	6	95.6
1 5-8	7.0	6 1-4	103.7
1 3-4	8.1	6 1-2	112.2
1 7-8	9.3	6 3-4	121.0
2	10.6	7	130.0
2 1-8	12.0	7 1-4	139.5
2 1-4	13.5	7 1-2	149.3
2 3-8	15.0	7 3-4	159.5
2 1-2	16.7	8	169.9
2 5-8	18.8	8 1-4	180.7
2 3-4	20.1	8 1-2	191.8
2 7-8	21.9	8 3-4	203.3
3	23.9	9	215.0
3 1-8	25.9	9 1-4	227.2
3 1-4	28.0	9 1-2	239.6
3 3-8	30.2	9 3-4	252.4
3 1-2	32.5	10	266.3
3 5-8	34.9	10 1-4	278.9
3 3-4	37.3	10 1-2	292.7
3 7-8	39.9	10 3-4	306.8
4	42.5	11	321.2
4 1-8	45.2	11 1-4	336.0
4 1-4	48.0	11 1-2	351.1
4 3-8	50.8	11 3-4	366.5
4 1-2	53.8	12	382.2
4 5-8	56.8		

Weight of a Square Foot of Wrought Iron, Copper and Lead, from 1-16 *to* 2 *Inches thick.*

	Wrought Iron, Hard Rol'd.	Copper, Hard Rol'd.	Lead.
1-16	2.517	2.890	3.691
1-8	5.035	5.741	7.382
3-16	7.552	8.672	11.074
1-4	10.070	11.562	14.765
5-16	12.588	14.453	18.456
3-8	15.106	17.344	22.148
7-16	17.623	20.234	25.839
1-2	20.141	23.125	29.530
9-16	22.659	26.106	33.222
5-8	25.176	28.906	36.913
11-16	27.694	31.797	40.604
3-4	30.211	34.688	44.296
13-16	32.729	37.578	47.987
7-8	35.247	40.469	51.678
15-16	37.764	43.359	55.370
1	40.282	46.250	59.061
1⅛	45.317	52.031	66.444
1¼	50.352	57.813	73.826
1⅜	55.387	63.594	81.210
1½	60.422	69.375	88.592
1⅝	65.458	75.156	95.975
1¾	70.493	80.938	103.358
1⅞	75.528	86.719	110.740
2	80.563	92.500	118.128

Weight of Copper Bolts from 1-4 *to* 4 *Inches in Diameter, and* 1 *foot in Length.*

Diameter.	Pounds.	Diameter.	Pounds.
1-4	.1892	1 9-16	7.3898
5-16	.2956	1 5-8	7.9931
3-8	.4256	1 3-4	9.2702
7-16	.5794	1 7-8	10.6420
1-2	.7567	2	12.1082
9-16	.9578	2 1-8	13 6677
5-8	1.1824	2 1-4	15.3251
11-16	1.4307	2 3-8	17.0750
3-4	1.7027	2 1-2	18.9161
13-16	1.9982	2 5-8	20.8562
7-8	2.3176	2 3-4	22.8913
15-16	2 6605	2 7-8	25.0188
1	3.0270	3	27.2435
1 1-16	3.4170	3 1-8	29.5594
1 1-8	3.8312	3 1-4	33.9722
1 3-16	4.2688	3 3-8	34.4815
1 1-4	4.7298	3 1-2	37.0808
1 5-16	5.2140	3 5-8	39.7774
1 3-8	5.7228	3 3-4	42.5680
1 7-16	6.2547	3 7-8	45.4550
1 1-2	6.3109	4	48.4330

TABLES
OF THE
Circumferences of Circles,
TO THE
NEAREST FRACTION OF PRACTICAL MEASUREMENT,

ALSO,

THE AREAS OF CIRCLES, IN INCHES, AND DECIMAL PARTS,
LIKEWISE IN FEET AND DECIMAL PARTS,
AS MAY BE REQUIRED.

Rules that may render the following Tables more generally useful.

1. Any of the areas in inches, multiplied by ·04328, or the areas in feet multiplied by 6·232, the product is the number of imperial gallons at 1 foot in depth.

2. Any of the areas in feet, multiplied by ·03704, the product equal the number of cubic yards at 1 foot in depth.

Dia. in inch.	Circum. in inch.	Area in sq. inch.	Side of = sq.	Dia in inch.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.
1-16	-196	-0030	-0554	4 in.	1 0½	12-566	-0879
1-8	-392	-0122	-1107	4⅛	1 0⅞	13-364	-0935
3-16	-589	-0276	-1661	4¼	1 1⅜	14-186	-0993
1-4	-785	-0490	-2115	4⅜	1 1¾	15-033	-1052
5-16	-981	-0767	-2669	4½	1 2⅛	15-904	-1113
3-8	1-178	-1104	·3223	4⅝	1 2½	16-800	-1176
7-16	1-374	-1503	-3771	4¾	1 2⅞	17-720	-1240
				4⅞	1 3¼	18-665	-1306
1-2	1-570	-1963	-4331	5 in.	1 3⅝	19-635	-1374
9-16	1-767	-2485	-4995	5⅛	1 4⅛	20-629	-1444
5-8	1-963	-3068	-5438	5¼	1 4½	21-647	-1515
11-16	2-159	-3712	-6093	5⅜	1 4⅞	22-690	-1588
3-4	2-356	-4417	-6646	5½	1 5¼	23-758	-1663
13-16	2-552	-5185	-7200	5⅝	1 5⅝	24-850	-1739
7-8	2-748	-6013	-7754	5¾	1 6	25·967	-1817
15-16	2-945	-6903	-8308	5⅞	1 6⅜	27-108	-1897
1 in.	3⅛	-7854	⅞	6 in.	1 6¾	28-274	-1979
1⅛	3½	-9940	⅞ & 3-32	6⅛	1 7¼	29-464	-2062
1¼	3⅞	1-227	1 in.	6¼	1 7⅝	30-679	-2147
1⅜	4¼	1-484	1 3-16	6⅜	1 8	31-919	-2234
1½	4⅝	1-767	1 5-16	6½	1 8⅜	33-183	-2322
1⅝	5⅛	2-074	1 7-16	6⅝	1 8¾	34·471	-2412
1¾	5½	2-405	1 9-16	6¾	1 9⅛	35-784	-2504
1⅞	5⅞	2-761	1 11-16	6⅞	1 9½	37-122	-2598
2 in.	6¼	3-141	1¾	7 in.	1 10	38-484	-2693
2⅛	6⅝	3-546	1⅞	7⅛	1 10⅜	39-871	-2791
2¼	7	3-976	2 in.	7¼	1 10¾	41-282	-2889
2⅜	7⅜	4-430	2 ⅛	7⅜	1 11⅛	42-718	-2990
2½	7¾	4-908	2 3-16	7½	1 11½	44-178	-3092
2⅝	8¼	5-412	2 5-16	7⅝	1 11⅞	45-663	-3196
2¾	8⅝	5-939	2 7-16	7¾	2 0⅜	47-173	-3299
2⅞	9	6-491	2 9-16	7⅞	2 0¾	48-707	-3409
3 in.	9⅜	7-068	2⅝	8 in.	2 1⅛	50-265	-3518
3⅛	9¾	7-669	2¾	8⅛	2 1½	51-848	-3629
3¼	10¼	8-295	2⅞	8¼	2 1⅞	53-456	-3741
3⅜	10⅝	8-946	3 in.	8⅜	2 2¼	55-088	-3856
3½	11	9-621	3⅛	8½	2 2⅝	56-745	-3972
3⅝	11⅜	10-320	3¼	8⅝	2 3	58-426	-4089
3¾	11¾	11-044	3⅜	8¾	2 3⅜	60-132	-4209
3⅞	12⅛	11-793	3 7-16	8⅞	2 3⅞	61-862	-4330

Dia. in inch.	Cir. in		Area in sq. inch.	Area in sq. ft.	Dia. in inch.	Cir. in		Area in sq. inch.	Area of sq. ft.
	ft.	in.				ft.	in.		
9 in.	2	4¼	63·617	·4453	14 in.	3	7⅞	153·938	1·0775
9⅛	2	4⅝	65·396	·4577	14⅛	3	8⅜	156·699	1·0968
9¼	2	5	67·200	·4704	14¼	3	8¾	159·485	1·1193
9⅜	2	5⅜	69·029	·4832	14⅜	3	9⅛	162·295	1·1360
9½	2	5¾	70·882	·4961	14½	3	9½	165·130	1·1569
9⅝	2	6¼	72·759	·5093	14⅝	3	9⅞	167·989	1 1749
9¾	2	6⅝	74·662	·5226	14¾	3	10¼	170·873	1·1961
9⅞	2	7	76·588	·5361	14⅞	3	10¾	173·782	1·2164
10 in.	2	7⅜	78·540	·5497	15 in.	3	11⅛	176·715	1·2370
10⅛	2	7¾	80·515	·5636	15⅛	3	11½	179·672	1·2577
10¼	2	8⅛	82·516	·5776	15¼	3	11⅞	182·654	1·2785
10⅜	2	8½	84·540	·5917	15⅜	4	0¼	185·661	1·2996
10½	2	8⅞	86·590	·6061	15½	4	0⅝	188·692	1·3208
10⅝	2	9⅜	88·664	·6206	15⅝	4	1	191·748	1·3422
10¾	2	9¾	90·762	·6353	15¾	4	1½	194·828	1·3637
10⅞	2	10⅛	92·855	·6499	15⅞	4	1⅞	197·933	1·3855
11 in.	2	10½	95·033	·6652	16 in.	4	2¼	201·062	1·4074
11⅛	2	10⅞	97·205	·6874	16⅛	4	2⅝	204·216	1·4295
11¼	2	11¼	99·402	·6958	16¼	4	3	207·394	1·4517
11⅜	2	11¾	101·623	·7143	16⅜	4	3⅜	210·597	1·4741
11½	3	0⅛	103·869	·7290	16½	4	3¾	213·825	1·4967
11⅝	3	0½	106·139	·7429	16⅝	4	4¼	217·077	1·5195
11¾	3	0⅞	108·434	·7590	16¾	4	4⅝	220·353	1·5424
11⅞	3	1¼	110·753	·7752	16⅞	4	5	223 654	1·5655
12 in.	3	1⅝	113·097	·7916	17 in.	4	5⅜	226·980	1·5888
12⅛	3	2	115·466	·8082	17⅛	4	5¾	230·330	1·6123
12¼	3	2½	117·859	·8250	17¼	4	6⅛	233·705	1·6359
12⅜	3	2⅞	120·276	·8419	17⅜	4	6½	237·104	1·6597
12½	3	3¼	122·718	·8590	17½	4	6⅞	240·528	1·6836
12⅝	3	3⅝	125·185	·8762	17⅝	4	7⅜	243·977	1·7078
12¾	3	4	127·676	·8937	17¾	4	7¾	247·450	1·7321
12⅞	3	4⅜	130·192	·9113	17⅞	4	8⅛	250·947	1·7566
13 in.	3	4¾	132·732	·9291	18 in.	4	8½	254·469	1·7812
13⅛	3	5¼	135·297	·9470	18⅛	4	8⅞	258·016	1·8061
13¼	3	5⅝	137·886	·9642	18¼	4	9¼	261·587	1·8311
13⅜	3	6	140·500	·9835	18⅜	4	9¾	265·182	1·8562
13½	3	6⅜	143·139	1·0019	18½	4	10⅛	268·803	1·8816
13⅝	3	6¾	145·802	1·0206	18⅝	4	10½	272·447	1·9071
13¾	3	7⅛	148·489	1·0294	18¾	4	10⅞	276·117	1·9328
13⅞	3	7½	151·201	1·0584	18⅞	4	11¼	279·811	1·9586

Dia. in inch.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.	Dia. in ft. in.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.
19 in.	4 11⅝	283-529	1-9847	2 0	6 3⅜	452-390	3-1418
19⅛	5 0	287-272	1-9941	2 0¼	6 4⅛	461-864	3-2075
19¼	5 0½	291-039	2-0371	2 0½	6 4⅞	471-436	3-2731
19⅜	5 0⅞	294-831	2-0637	2 0¾	6 5¾	481-106	3-3410
19½	5 1¼	298-648	2-0904	2 1	6 6½	490-875	3-4081
19⅝	5 1⅝	302-489	2-1172	2 1¼	6 7¼	500-741	3-4775
19¾	6 2	306-355	2 1443	2 1½	6 8⅛	510-706	3-5468
19⅞	5 2⅜	310-245	2-1716	2 1¾	6 8⅞	520-760	3-6101
20 in.	5 2⅞	314-160	2-1990	2 2	6 9⅝	530-930	3-6870
20⅛	5 3¼	318-099	2-2265	2 2¼	6 10½	541-189	3-7583
20¼	5 3⅝	322-063	2-2543	2 2½	6 11¼	551-547	3-8302
20⅜	5 4	326-051	2-2822	2 2¾	7 0	562-002	3-9042
20½	5 4⅜	330-064	2-3103	2 3	7 0¾	572-556	3-9761
20⅝	5 4⅞	334-101	2-3386	2 3¼	7 1⅝	583-208	4-0500
20¾	5 5⅛	338-163	2-3670	2 3½	7 2⅜	593-958	4-1241
20⅞	5 5½	342-250	2-3956	2 3¾	7 3⅛	604-807	4-2000
21 in.	5 5⅞	346-361	2-4244	2 4	7 3⅞	615-753	4-2760
21⅛	5 6⅜	350-497	2-4533	2 4¼	7 4¾	626-798	4-3521
21¼	5 6¾	354-657	2-4824	2 4½	7 5½	637-941	4-4302
21⅜	5 7⅛	358-841	2-5117	2 4¾	7 6¼	649-182	4-5083
21½	5 7½	363-051	2-5412	2 5	7 7	660-521	4-5861
21⅝	5 7⅞	367-284	2-5708	2 5¼	7 7⅞	671-958	4 6665
21¾	5 8¼	371-543	2-6007	2 5½	7 8⅝	683-494	4-7467
21⅞	5 8¾	375-826	2-6306	2 5¾	7 9½	695-128	4-8274
22 in.	5 9⅛	380-133	2-6608	2 6	7 10¼	706-860	4-9081
22⅛	5 9½	384-465	2-6691	2 6¼	7 11	718-690	4-9901
22¼	5 9⅞	388-822	2-7016	2 6½	7 11¾	730-618	5-0731
22⅜	5 10¼	393-203	2-7224	2 6¾	8 0⅝	742-644	5-1573
22½	5 10⅝	397-608	2-7632	2 7	8 1⅜	754-769	5-2278
22⅝	5 11	402-038	2-7980	2 7¼	8 2⅛	766-992	5-3264
22¾	5 11½	406-493	2-8054	2 7½	8 2⅞	779-313	5-4112
22⅞	5 11⅞	410-972	2-8658	2 7¾	8 3¾	791-732	5-4982
23 in.	6 0¼	415-476	2-8903	2 8	8 4½	804-249	5-5850
23⅛	6 0⅝	420-004	2-9100	2 8¼	8 5⅜	816-865	5-6729
23¼	6 1	424-557	2-9518	2 8½	8 6⅛	829-578	5 7601
23⅜	6 1⅜	429-135	2-9937	2 8¾	8 6⅞	842-390	5-8491
23½	6 1¾	433-737	3-0129	2 9	8 7⅝	855-300	5-9398
23⅝	6 2¼	438-363	3-0261	2 9¼	8 8½	868-308	6-0291
23¾	6 2⅝	443-014	3-0722	2 9½	8 9¼	881-415	6-1201
23⅞	6 3	447·690	0-1081	2 9¾	8 10	894-619	6-2129

Dia. in ft. in.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.	Dia. in ft. in.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.
2 10	8 10¾	907-922	6-3051	3 8	11 6¼	1530-53	10-559
2 10¼	8 11⅝	921-323	6-3981	3 8¼	11 7	1537-86	10-679
2 10½	9 0⅜	934-822	6-4911	3 8½	11 7¾	1555-28	10-800
2 10¾	9 1⅛	948-419	6-5863	3 8¾	11 8⅝	1572-81	10-922
2 11	9 1⅞	962-115	6-6815	3 9	11 9⅜	1590-43	11-044
2 11¼	9 2¾	975-908	6-7772	3 9¼	11 10⅛	1608-15	11-167
2 11½	9 3½	989-800	6-8738	3 9½	11 10⅞	1625-97	11 291
2 11¾	9 4¼	1003-79	6-9701	3 9¾	11 11¾	1643-89	11-415
3 0	9 5	1017-87	7-0688	3 10	12 0½	1661-90	11-534
3 0¼	9 5⅞	1032-06	7-1671	3 10¼	12 1¼	1680-02	11-666
3 0½	9 6⅝	1046-35	7-2664	3 10½	12 2	1698-23	11-793
3 0¾	9 7½	1060-73	7-3662	3 10¾	12 2⅞	1716-54	11-920
3 1	9 8¼	1075-21	7-4661	3 11	12 3⅝	1734-94	12-048
3 1¼	9 9	1089-79	7-5671	3 11¼	12 4½	1753-45	12-176
3 1½	9 9⅞	1104-46	7-6691	3 11½	12 5¼	1772-05	12-305
3 1¾	9 10⅝	1119-24	7-7791	3 11¾	12 6	1790-76	12-435
3 2	9 11⅜	1134-12	7-8681	4 0	12 6¾	1809-56	12-566
3 2¼	10 0⅛	1149-09	7-9791	4 0¼	12 7½	1828-46	12-697
3 2½	10 0⅞	1164-16	8-0846	4 0½	12 8⅜	1847-45	12-829
3 2¾	10 1¾	1179-32	8-1891	4 0¾	12 9⅛	1866-55	12-962
3 3	10 2½	1194-59	8-2951	4 1	12 9⅞	1885-74	13-095
3 3¼	10 3¼	1209-95	8-4026	4 1¼	12 10¾	1905-03	13-229
3 3½	10 4	1225-42	8-5091	4 1½	12 11½	1924-42	13-364
3 3¾	10 4⅞	1240-98	8-6171	4 1¾	13 0¼	1943-91	13-499
3 4	10 5⅝	1256-64	8-7269	4 2	13 1	1963-50	13-635
3 4¼	10 6⅜	1272-39	8-8361	4 2¼	13 1⅞	1983-18	13-772
3 4½	10 7¼	1288-25	8-9462	4 2½	13 2⅝	2002-96	13-909
3 4¾	10 8	1304-20	9-0561	4 2¾	13 3⅜	2022-84	14-047
3 5	10 8¾	1320-25	9-1686	4 3	13 4¼	2042-82	14-186
3 5¼	10 9⅝	1336-40	9-2112	4 3¼	13 5	2062-90	14-325
3 5½	10 10⅜	1352-65	9-3936	4 3½	13 5¾	2083-07	14-465
3 5¾	10 11⅛	1369-00	9-5061	4 3¾	13 6½	2103-35	14-606
3 6	10 11⅞	1385-44	9-6212	4 4	13 7⅜	2123-72	14-748
3 6¼	11 0¾	1401-98	9-7364	4 4¼	13 8⅛	2144-19	14-890
3 6½	11 1½	1418-62	9-8518	4 4½	13 8⅞	2164-75	15-033
3 6¾	11 2¼	1435-36	9-9671	4 4¾	13 9¾	2185-42	15-176
3 7	11 3	1452-20	10-084	4 5	13 10½	2206-18	15-320
3 7¼	11 3⅞	1469-14	10-202	4 5¼	13 11¼	2227-05	15-465
3 7½	11 4⅝	1486-17	10-320	4 5½	14 0	2248-01	15-611
3 7¾	11 5⅜	1503-30	10-439	4 5¾	14 0⅞	2269-06	15-757

Dia. in		Cir. in		Area in sq. inch.	Area in sq. ft.	Dia. in		Cir. in		Area in sq. inch.	Area in sq. ft.
ft.	in.	ft.	in.			ft.	in.	ft.	in.		
4	6	14	1⅝	2290·22	15-904	5	4	16	9	3216-99	22-333
4	6¼	14	2⅜	2311-48	16-051	5	4¼	16	9¾	3242-17	22-515
4	6½	14	3¼	2332-83	16-200	5	4½	16	10⅝	3267-46	22-621
4	6¾	14	4	2354-28	16-349	5	4¾	16	11⅜	3292-83	22-866
4	7	14	4¾	2375-83	16-498	5	5	17	0⅛	3318-31	23-043
4	7¼	14	5½	2397-48	16-649	5	5¼	17	0⅞	3343-88	23-221
4	7½	14	6⅜	2419-22	16-800	5	5½	17	1¾	3369-56	23-330
4	7¾	14	7⅛	2441-07	16-951	5	5¾	17	2½	3395-33	23-578
4	8	14	7⅞	2463-01	17-104	5	6	17	3⅜	3421-20	23·758
4	8¼	14	8⅝	2485-05	17-257	5	6¼	17	4⅛	3447-16	23-938
4	8½	14	9½	2507-19	17-411	5	6½	17	4⅞	3473-23	24-119
4	8¾	14	10¼	2529-42	17-565	5	6¾	17	5⅝	3499-39	24-301
4	9	14	11	2551-76	17-720	5	7	17	6½	3525-26	24-483
4	9¼	14	11⅞	2574-19	17-876	5	7¼	17	7¼	3552-01	24-666
4	9½	15	0⅝	2596-72	18-033	5	7½	17	8	3578-47	24-850
4	9¾	15	1⅜	2619-35	18-189	5	7¾	17	8¾	3605-03	25-034
4	10	15	2¼	2642-08	18-347	5	8	17	9⅝	3631-68	25-220
4	10¼	15	2⅞	2664-91	18-506	5	8¼	17	10⅜	3658-44	25-405
4	10½	15	3¾	2687-83	18-665	5	8½	17	11⅛	3685-29	25-592
4	10¾	15	4½	2710-85	18-825	5	8¾	17	11⅞	3712-24	25-779
4	11	15	5¼	2733-97	18-985	5	9	18	0¾	3739-28	25-964
4	11¼	15	6⅛	2757-19	19-147	5	9¼	18	1½	3766-43	26-155
4	11½	15	6⅞	2780-51	19-309	5	9½	18	2¼	3793-67	26-344
4	11¾	15	7¾	2803-92	19-471	5	9¾	18	3⅛	3821-02	26-534
5	0	15	8½	2827-44	19-635	5	10	18	3⅞	3848-46	26-725
5	0¼	15	9¼	2851-05	19-798	5	10¼	18	4⅝	3875-99	26-916
5	0½	15	10	2874-76	19-963	5	10½	18	5½	3903-63	27-108
5	0¾	15	10⅞	2898-56	20-128	5	10¾	18	6¼	3931-36	27-301
5	1	16	11⅝	2922-47	20-294	5	11	18	7	3959-20	27-494
5	1¼	16	0⅜	2946-47	20-461	5	11¼	18	7¾	3987-13	27-688
5	1½	16	1¼	2970-57	20 629	5	11½	18	8⅝	4015-16	27 883
5	1¾	16	1⅞	2994-77	20-797	5	11¾	18	9⅜	4043-28	28-078
5	2	16	2¾	3019·07	20-965	6	0	18	10⅛	4071-51	28-274
5	2¼	16	3½	3043-47	21-135	6	0¼	18	10⅞	4099·83	28-471
5	2½	16	4¼	3067-96	21-305	6	0½	18	11¾	4128-25	28 663
5	2¾	16	5⅛	3092-56	21-476	6	0¾	19	0½	4156-77	28·866
5	3	16	5⅞	3117-25	21-647	6	1	19	1¼	4185-39	29·065
5	3¼	16	6¾	3142-04	21-819	6	1¼	19	2⅛	4214-11	29·264
5	3½	16	7½	3166-92	21-992	6	1½	19	2⅞	4242-92	29-466
5	3¾	16	8¼	3191-91	22-166	6	1¾	19	3⅝	4271-83	29-665

Dia. in ft.	in.	Cir. in ft.	in.	Area in sq. inch.	Area in sq. ft.	Dia. in ft.	in.	Cir. in ft.	in.	Area in sq. inch.	Area in sq. ft.
6	2	19	4½	4300-85	29-867	6	8	20	11¼	5026-26	34-906
6	2¼	19	5¼	4329-95	30-069	6	8¼	21	0⅛	5058-02	35-125
6	2½	19	6	4359-16	30-271	6	8½	21	0⅞	5089-58	35-344
6	2¾	19	6¾	4388-47	30-475	6	8¾	21	1⅝	5121-24	35-564
6	3	19	7⅝	4417-87	30-679	6	9	21	2⅜	5153-00	35-784
6	3¼	10	8⅜	4447-37	30-884	6	9¼	21	3¼	5184-86	36-006
6	3½	19	9⅛	4476-97	31-090	6	9½	21	4	5216-82	36-227
6	3¾	19	9⅞	4506-67	31-296	6	9¾	21	4¾	5248-87	36-450
6	4	19	10¾	4536-47	31-503	6	10	21	5½	5281-02	36·674
6	4¼	19	11½	4566-36	31-710	6	10¼	21	6⅜	5313-27	36-897
6	4½	20	0¼	4596-35	31-919	6	10½	21	7⅛	5345-62	37-122
6	4¾	20	1⅛	4626-44	32-114	6	10¾	21	7⅞	5378-07	37-347
6	5	20	1⅞	4656-63	32-337	6	11	21	8¾	5410-62	37-573
6	5¼	20	2⅝	4686-92	32-548	6	11¼	21	9½	5443-26	37-700
6	5½	20	3½	4717-30	32 759	6	11½	21	10¼	5476-00	38-027
6	5¾	20	4¼	4747-79	32-970	6	11¾	21	11	5508-84	38-256
6	6	20	5	4778-37	33-183						
6	6¼	20	5¾	4809-05	33-396						
6	6½	20	6½	4839-83	33-619						
6	6¾	20	7⅜	4870-70	33-824						
6	7	20	8⅛	4901-68	34-039						
6	7¼	20	8⅞	4932-75	34-255						
6	7½	20	9¾	4963-92	34-471						
6	7¾	20	10½	4995-19	34-688						

Dia. in ft. and in.	Circum. in ft. and in.	Area in ft.	Diam. in ft. and in.	Circum. in ft. and in.	Area in ft.
7 0	21 11⅞	38-4846	10 0	31 5	78-5400
1	22 3	39-4060	1	31 8⅛	79-8540
2	22 6⅛	40-3388	2	31 11¼	81-1795
3	22 9¼	41-2825	3	32 2⅜	82-5190
4	23 0⅜	42-2367	4	32 5½	83-8627
5	23 2⅛	43-2022	5	32 8⅝	85-2211
6	23 6¾	44-1787	6	32 11¾	86-5903
7	23 11	45-1656	7	33 2⅞	87-9697
8	24 1⅛	46-1638	8	33 6⅛	89-3668
9	24 4⅛	47-1730	9	33 9¼	90-7627
10	24 7¼	48-1926	10	34 0⅜	92-1749
11	24 10⅜	49-2236	11	34 3½	93-5986
8 0	25 1½	50-2656	11 0	34 6⅝	95-0334
1	25 4⅝	51-6178	1	34 9¾	96-4783
2	25 7⅞	52-3816	2	35 0⅞	97-9347
3	25 11	53-4562	3	35 4⅛	99-4021
4	26 2⅛	54-5412	4	35 7¼	100-8797
5	26 5¼	55-6377	5	35 10⅜	102-3689
6	26 8⅜	56-7451	6	36 1½	103-8601
7	26 11½	57-8628	7	36 4½	105-3794
8	27 2¾	58-9920	8	36 7¾	106-9013
9	27 5¾	60-1321	9	36 10⅞	108-4342
10	27 9	61-2826	10	37 2¾	109-9772
11	28 0⅛	62-4445	11	37 5¼	111-5319
9 0	28 3¼	63-6174	12 0	37 8⅜	113-0976
1	28 6⅜	64-8006	1	37 11½	114-6732
2	28 9½	65-9951	2	38 2⅝	116-2607
3	29 0⅝	67-2007	3	38 5¾	117-8590
4	29 3¾	68-4166	4	38 8⅞	119-4674
5	29 7	69-6440	5	39 0	121-0876
6	29 10⅛	70-8823	6	39 3¼	122-7187
7	30 1¼	72-1309	7	39 6⅜	124-3598
8	30 4⅜	73-3910	8	39 9½	126-0127
9	30 7½	74-6620	9	40 0⅝	127-6765
10	30 11⅝	75-9433	10	40 3¾	129-3504
11	31 1¾	77-2362	11	40 6⅞	131-0360

Dia. in ft. and in.	Circum. in ft. and in.	Area in ft.	Diam in ft. and in.	Circum. in ft. and in.	Area in ft.
13 0	40 10	132-7326	16 0	50 3⅛	201-0624
1	41 1⅛	134-4391	1	50 6¼	203-1615
2	41 4⅜	136-1574	2	50 9⅝	205-2726
3	41 7½	137-8867	3	51 0½	207-3946
4	41 10⅝	139-6260	4	51 3¾	209-5264
5	42 1⅝	141-3771	5	51 6⅞	211-6703
6	42 4⅞	143-1391	6	51 10	213-8251
7	42 8	144-9111	7	52 1⅛	215-9896
8	42 11⅛	146-6949	8	52 4¼	218-1662
9	43 2¼	148 4896	9	52 7⅜	220-3537
10	43 5½	150-2943	10	52 10½	222-5510
11	43 8⅝	152-1109	11	53 1⅝	224-7603
14 0	43 11¾	153-9484	17 0	53 4⅞	226-9806
1	44 2⅞	155 7758	1	53 8	229-2105
2	44 6	157-6250	2	53 11⅛	231-4625
3	44 9⅛	159 4852	3	54 2¼	233-7055
4	45 0¼	161-3553	4	54 5⅜	235-9682
5	45 3½	163-2373	5	54 8½	238-2430
6	45 6⅝	165-1303	6	54 11⅝	240-5287
7	45 9¾	167-0331	7	55 2⅞	242-8241
8	46 0⅞	168-9479	8	55 6	245-1316
9	46 4	170-8735	9	55 9⅛	247-4500
10	46 7⅛	172-8091	10	56 0¼	249-7781
11	46 11¼	174·7565	11	56 3⅜	252·1164
15 0	47 1½	176-7150	18 0	56 6½	254·4696
1	47 4⅝	178-6832	1	56 9⅝	256-8303
2	47 7¾	180-6634	2	57 0⅞	259-2033
3	47 10⅞	182-6545	3	57 4	261-5872
4	48 2½	184-6555	4	57 7⅛	263-9807
5	48 5⅛	186-6684	5	57 10¼	266-3864
6	48 8¼	188-6923	6	58 1⅜	268-8031
7	48 11⅜	190-7260	7	58 4½	271-2293
8	49 2⅝	192-7716	8	58 7⅝	273-6678
9	49 5¾	194-8282	9	58 10¾	276-1171
10	49 8⅞	196-8946	10	59 2	278-5761
11	50 0	198-9730	11	59 5⅛	281-0472

Sizes of Tin-ware in form of Frustrum of a cone.

PANS.

Size.	Diam. of top.	Diam. of bot.	Height.	Size.	Diam. of top.	Diam. of bot.	Height
20 qt.	19½ in	13 in	8 in	2 qt.	9 in	6 in	3¾ in
16 "	18	11½	6½	3 pt.	8½	5¾	2½
14 "	15½	9½	6½	1 "	6½	4	2¾
10 "	14¾	11	4½	Pie	9	7½	1¾
6 "	12¾	9	4				

DISH KETTLES AND PAILS.

Size.	Diam. of top.	Diam. of bot.	Height.	Size.	Diam. of top.	Diam. of bot.	Height.
14 qt.	18 in	9 in	9 in	6 qt.	9½ in	5½ in	6½ in
10 "	11½	7	8	2 "	6½	4	4

COFFEE POTS

Size.	Diam. of top.	Diam. of bot.	Height.	Size.	Diam. of top.	Diam. of bot.	Height.
1 gal.	4 in	7 in	8½ in	3 qt.	8½ in	6 in	8½ in

WASH BOWLS.

Size.	Diam. of top.	Diam. of bot.	Height.
Large Wash Bowl..................	11 in.	5¾ in.	5 in
Culinder..............................	11	5¾	5
Small Wash Bowl....................	9½	5½	3¾
Milk Strainer.........................	9½	5½	3¾

DIPPERS.

Size,	Diam, of top;	Diam, of bot,	Height.	Size,	Diam, of top;	Diam; of bot,	Height;
½ gal.	6½ in	4 in	4 in	1 pt.	4¼ in	3¾ in	2¾ in

MEASURES.

Size.	Diam, of top;	Diam, of bot.	Height,	Size.	Diam. of top;	Diam, of bot,	Height,
1 gal.	5½ in	6⅛ in	9½ in	1 pt.	2⅛ in	3¾ in	4½ in
½ "	4	4⅞	8	½ "	2⅝	2⅞	3⅛
1 qt.	3½	4	5¾				

DRUGGISTS' AND LIQUOR DEALERS' MEASURES.

Size.	Diam. of top.	Diam, of bot.	Height.	Size.	Diam. of top.	Diam. of bot.	Height
5 gal.	8 in	13½ in	12⅝ in	½ gal.	3⅛ in	6⅜ in	6 in
3 "	7	11½	10⅛	1 qt.	2½	5⅛	4⅞
2 "	6	10½	8⅝	1 pt.	2	4	4
1 "	3¾	8¾	7½	½ "	1¾	3¾	3⅛

American Lap Weled Iron Boiler Flues, Manufactured by the READING IRON COMPANY.

Outside Diameter.	W. G. Nos.	Weight per Foot, about,	Outside Diameter,	W, G, Nos;	Weight per Foot. about
1¼ in.	16	1 lb.	3¼	11	4
1½	15	1 1-10	3½	10	4¾
1¾	14	1½	4	10	5½
2	13	2	5	9	7½
2¼	12	2½	6	8	10
2½	12	2¾	7	7	13
2¾	11	3¼	8	6	
3	11	3½			

Table of Effects upon Bodies by Heat.

	FAHRENHEIT.
Cast Iron thoroughly smelts at	2754°
Fine Gold melts "	1983°
Fine Silver melts "	1850°
Copper melts "	2160°
Brass melts "	1900°
Zinc melts "	740°
Lead melts "	594°
Bismuth melts "	476°
Tin melts "	421°
Tin and Bismuth equal parts melt "..................	283°
Tin 3 parts Bismuth 5 and Lead 2 melt ".	212°

WEIGHT OF WATER.

1	cubic inch	is equal to	.03617	pounds.
12	cubic inches	is equal to	.434	pounds.
1	cubic foot	is equal to	62.5	pounds.
1	cubic foot	is equal to	7.50	U. S. gallons.
1.8	cubic feet	is equal to	112.00	pounds.
35.84	cubic feet	is equal to	2240.00	pounds.
1	Cylindrical inch	is equal to	.02842	pounds.
12	Cylindrical inches	is equal to	.341	pounds.
1	Cylindrical foot,	is equal to	49.10	pounds.
1	Cylindrical foot,	is equal to	6.00	U. S. gallons.
2.282	Cylindrical feet	is equal to	112.00	pounds.
45.64	Cylindrical feet	is equal to	2240.00	pounds.
11.2	Imperial gallons	is equal to	112.00	pounds.
224	Imperial gallons	is equal to	2240.00	pounds.
13.44	United States galls.	is equal to	112.00	pounds.
268.8	United States galls.	is equal to	2240.00	pounds.

Centre of pressure is at two-thirds depth from surface.

EFFECTS PRODUCED BY WATER IN AN AËRIFORM STATE.

When water in a vessel is subjected to the action of fire it readily imbibes the heat, or fluid principle of which the fire is the immediate cause, and sooner or latter, according to the intensity of the heat, attains a temperature of 212° Fahrenheit. If, at this point of temperature, the water be not enclosed, but exposed to atmospheric pressure, ebullition will take place, and steam or vapor will ascend through the water, carrying with it the superabundant heat, or that which the water cannot, under such circumstances of pressure, absorb, to be retained, and to indicate a higher temperture.

Water, in attaining the aëriform state, is thus uniformly confined to the same laws, under every degree of pressure; but, as the pressure is augmented, so is the indicated temperature proportionately elevated. Hence the various densities of steam, and corresponding degrees of elastic force.

PRACTICAL PROPERTIES OF WATER.

By analysis it is ascertained, that water is composed of the gases oxygen and hydrogen in a state of chemical union; its distinguishing properties, like that of other liquids, being nearly incompressible gravity, capability of flowing, and constant tendency to press outwards in every direction; also that of being easily changed by the absorption of caloric to an aeriform state of any required density or degree of elastic force: hence the principle of the hydraulic press, the water-wheel, the steam engine, &c.

Effects produced by Water in its Natural State.

Because of liquids possessing the properties of gravity and capability of flowing freely in every direction, sides of vessels, flood-gates, sluices, &c., sustain a pressure equal to the product of the area multiplied by half the depth of the fluid, and by its gravity in equal terms of unity.

But when a sluice or opening through which a liquid may issue is under any given continued head, the pressure is equal the product of the area multiplied into the height from the centre of the opening to the surface of the fluid.

Example 1.—Required the pressure of water on the sides of a cistern 18 feet in length, 13 in width and 9 in depth.

The terms of measurement or unity are in feet; 1 cubic foot of water = 62·5 lbs.; hence,

18 × 9 × 2 + 13 × 9 × 2 — 558 × 4·5 × 62.5 = 156937.5 lbs.

weight of water on bottom = 18 × 13 × 9 × 62.5 = 131625 lbs.

Example 2.—Required the pressure on a sluice 3 feet square, and its centre 30 feet from the surface of the water

3 × 3 × 30 × 62.5 = 16875 lbs. pressure.

HEAT.

Effects of Heat at certain Temperatures.—Grier.

Tin and Bismuth, equal parts, melt at 283 degrees, Fahrenheit; tin melts at 442; polished steel acquires straw color at 460; bismuth melts at 476; sulphur burns at 560; oil of turpentine boils at 560; polished steel acquires deep blue color at 580; lead melts at 594; linseed oil boils at 600; quicksilver boils at 660; zinc melts at 700; iron, bright red in the dark at 752; iron, red-hot in twilight at 884; red heat fully visible in daylight at 1077; brass melts at 3807; copper melts at 4587; silvers melts at 4717; gold melts at 5237; welding heat of iron, from 12777; welding heat of iron, to 13427; greatest heat of smith's forge 17327; cast iron begins to melt at 17977; cast iron thoroughly melted at 20577.

TEMPERING.

The article after being completed, is hardened by being heated gradually to a bright red, and then plunged into cold water; it is then tempered by being warmed gradually and equably, either over a fire, or on a piece of heated metal till of the color corresponding to the purpose for which it is required, as per table below, when it is again plunged into water.

Corresponding	Temperature.		
A very pale straw	430°	Lancets	
Straw	450°	Razors	
Darker straw	470°	Penknives	All kinds of wood tools
Yellow	490°	Scissors	Screw taps.
Brown yellow	500°	Hatchets, Chipping Chisels,	
Slightly tinged purple	520°	Saws.	
Purple	530°	All kinds of percussive tools.	
Dark purple	550°	Springs.	
Blue	570°		
Dark blue	600°	Soft for saws.	

To Temper by the Thermometer.

Put the articles to be tempered into a vessel cantaining sufficient quantity to cover them, of Oil or Tallow; Sand; or a mixture of 8 parts bismuth, 5 of lead, and 3 of tin, the whole to be brought up to, and kept up at the heat corresponding to the hardness required, by means of a suitable thermometer, till heated equally throughout; the articles are then withdrawn and plunged into cold water.

If no thermometer is available, it may be observed that oil or tallow begins to smoke at 430° or straw color, and that it takes fire on a light being presented, and goes out when the light is withdrawn, at 570° or blue.

EFFECTS PRODUCED BY AIR IN ITS NATURAL AND ALSO IN A RAREFIED STATE.

The weight or pressure of the atmosphere is equal to the weight of a column of water 34 feet in height, or to a column of mercury 30 inches in height, or to 14.7 lbs. average per square inch, at a mean temperature. But air, like all other gases, is rendered lighter by the application of heat; for then the particles of the mass are repelled from each other, or rarefied, and occupy a greater space. Rarefied air, being specifically lightest, mounts above that of common density; hence change of temperature, and the principle cause of winds.

Table of the Expansion of Atmospheric Air by Heat.

Degrees of Fahrenheit.	Bulk.	Degrees of Fahrenheit.	Bulk.	Degrees of Fahrenheit.	Bulk.
32°	1000	65°	1077	100°	1152
35	1007	70	1089	120	1194
40	1021	75	1099	140	1235
45	1032	80	1110	160	1275
50	1043	85	1121	180	1315
55	1055	90	1132	200	1364
60	1066	95	1142	212	1376

The pressure or gravity of the atmosphere, being equal to a column of water 34 feet in heieht, is the means or principle on which rests the utility of the common pump, also of the syphon and all other such hydraulic applications. In a pump, the internal pressure on the surface of the liquid is removed by the action of the bucket; and as by degrees the density becomes lessened, so the water rises by the external pressure to the above named height; and at such height it will remain, unless, by some derangement of construction taking place, the atmospheric fluid is allowed to enter and displace the liquid column. But observe, if the temperature of the water or other liquid be so elevated that steam or vapor arise through it, then, according to the vapor's accumulation of density, may the action of the pump be partially or wholly destroyed; and the only means of evasion in such cases is, to place the working bucket beneath the surface of the liquid which is required to be raised.

Size, Length, Breadth and Weight.

Brand Mark.	No. of Sheets in Box.	Length and Breadth.	Weight per Box.		
		Inches. Inches.	Cwt.	qr.	lbs.
1 C	225	14 by 10	1	0	0
1 x	225	14 by 10	1	1	0
1 xx	225	14 by 10	1	1	21
1 xxx	225	14 by 10	1	2	14
1 xxxx	225	14 by 10	1	3	7
1 xxxxx	225	14 by 10	2	0	0
1 xxxxxx	225	14 by 10	2	0	21
D C	100	17 by 12½	0	3	14
D x	100	17 by 12½	1	0	14
D xx	100	17 by 12½	1	1	7
D xxx	100	17 by 12½	1	2	0
D xxxx	100	17 by 12½	1	2	21
D xxxxx	100	17 by 12½	1	3	14
D xxxxxx	100	17 by 12½	2	0	7
S D C	200	15 by 11	1	1	27
S D x	200	15 by 11	1	2	20
S D xx	200	15 by 11	1	3	13
S D xxx	200	15 by 11	2	0	6
S D xxxx	200	15 by 11	2	0	27
S D xxxxx	200	15 by 11	2	1	20
S D xxxxxx	200	15 by 11	2	2	13

Crystallized Tin-Plate.

Crystallized tin-plate, is a variegated primrose appearance, produced upon the surface of tin-plate, by applying to it in a heated state some dilute nitro-muriatic acid for a few seconds, then washing it with water, drying, and coating it with lacker. The figures are more or less beautiful and diversified, according to the degree of heat, and relative dilution of the acid. Place the tin-plate slightly heated over a tub of water, and rub its surface with a sponge diped in a liquor composed of four parts of aquafortis, and two of distilled water, holding one of common salt sal ammoniac in solution. Whenever the crystalline spangles seem to be thoroughly brought out, the plate must be immersed in water, washed either with a feather or a little cotton (taking care not to rub off the film of tin that forms the feathering), forthwith dried with a low heat, and coated with a lacker varnish, otherwise it loses its lustre in the air. If the whole surface is not plunged at once in cold water, but if it be partially cooled by sprinkling water on it, the crystalliztion will be finely variegated with large and small figures. Similar results will be obtained by blowing cold air through a pipe on the tinned surface, while it is just passing from the fused to the solid state.

List of Calibre and Weights of Lead Pipe.

Calibre.		Weight per ft.		Av. length.	Calibre.		Weight per foot.		Av. length.
		lbs.	oz.	ft.			lbs.	oz.	ft.
¼ in.	light		8	300	1½ in.	medium .	5	4	28
	strong ...		12	225		strong ...	6	4	24
	ex. strong	1	4	120		ex. strong	7	2	21
⅜ in.	light		12	225	1¾ in.	ex. light .	3	12	42
	medium ..	1		150		light.....	4	8	33
	strong ...	1	8	100		medium..	5	8	27
	ex. strong	2		75		strong ...	6	8	23
½ in.	light	1		150		ex. strong	8	4	18
	medium ..	1	4	120	2 in.	ex. light .	4	8	33
	strong ...	1	12	85		light	5	8	27
	ex. strong	2	7	60		medium..	7		21
⅝ in.	ex. light .	1	4	120		strong ...	8		18
	light	1	12	85		ex. strong	9	8	15
	medium ..	2	4	65	2½ in.	3-16 thick	7	13	15
	strong ...	2	8	60		¼ thick ..	8	13	15
	ex. strong	3		50		5-16 thick	13	11	15
¾ in.	ex. light .	1	8	100		⅜ thick ..	16	12	15
	light.....	2		75	3 in.	waste. ..	5		15
	medium ..	2	8	60		3-16 thick	9	5	15
	strong ...	3		50		¼ thick ..	12	10	15
	ex. strong	3	10	43		5-16 thick	16		15
1 in.	ex. light .	2	4	65		⅜ thick ..	19	11	15
	light	2	12	55	3½ in.	¼ thick .	15		15
	medium ..	3	8	45		5-16 thick	18	5	15
	strong ...	4		38		⅜ thick ..	21	12	15
	ex. strong	3	12	42		7-16 thick	26	41	15
1¼ in.	ex. light .	2	12	55	4 in.	waste....	5	5	15
	light	3	4	46		¼ thick ..	16	12	15
	medium..	4		38		5-16 thick	21		15
	strong ...	4	8	33		⅜ thick ..	25	4	15
	ex. strong	6		25		7-16 thick	30		15
1½ in.	ex. light .	3	8	45	4½ in.	waste....	5	12	15
	light	4	4	35	5 in.	waste....	8		15

Calibre & Weights of Fountains or Aqueduct Pipes.

Very light Lead Pipe for Hydraulic Rams, and for conducting water at long distances, under slight pressure or head of water.

¼ inch........	6	1600	¾ inch........	1	2	550
⅜ inch........	8	1200	1 inch...	1	12	400
½ inch...	10	1000	1¼ inch........	2		250
⅝ inch........	12	900	1½ inch........	2	4	200

To ascertain the Weights of Pipes of various Metals, and any Diameter required.

Thick. Inch.	Wr'ght Iron.	Copper.	Lead.	Thick. Inch.	Wr'ght Iron.	Copper.	Lead.
1-32	.326	.38	.483	5-32	1.627	1.9	2.417
1-16	.653	.76	.967	3-16	1.95	2.28	2.9
3-32	.976	1.14	1.45	7-32	2.277	2.66	3.383
1-8	1.3	1.52	1.933	1-4	2.6	3.04	3.867

Rule.—To the interior diameter of the pipe, in inches, add the thickness of the metal; multiply the sum by the decimal number opposite the required thickness and under the metal's name; also by the length of the pipe in feet; and the product is the weight of the pipe in pounds.

1. Required the weight of a copper pipe, whose interior diameter is 2¼ inches, its length 20 feet, and the metal ⅛ of an inch in thickness.

$$2.25 + .125 = 2.375 \times 1.52 \times 20 = 72.2 \text{ lbs.}$$

Weight of a Square Foot of Sheet-Iron, Copper, and Brass, as per Birmingham Wire Gauge.

No. of Guage.	Iron.	Copper.	Brass.	No. of Guage.	Iron.	Galv. Iron.	Copper.	Brass.
1	12.5	14.5	13.75	16	2.62	3.	2.9	2.75
2	12.	13.9	13.2	17	2.20	2.69	2.52	2.4
3	11.	12.75	12.1	18	1.92	2.31	2.15	2.04
4	10.5	11.6	11.	19	1.75	2.07	1.97	1.87
5	9.	10.1	9.61	20	1.54	1.75	1.78	1.69
6	8.34	9.4	8.93	21	1.4	1.5	1.62	1.54
7	7.5	8.7	8.25	22	1.25	1.32	1.45	1.37
8	6.86	7.9	7.54	23	1.13	1.19	1.3	1.23
9	6.29	7.2	6.86	24	1.02	1.06	1.16	1.1
10	5.62	6.5	6.18	25	.9	1.	1.04	.99
11	5.	5,8	5.5	26	.8	.96	.92	.88
12	4.5	5.08	4.81	27	.75	.88	.83	.79
13	4.	4.34	4.12	28	.65	.75	.74	.7
14	3.23	3.6	3.43	29	.58	.69	.64	.61
15	2.97	3.27	3.1					

Recapitulation of Weights of Various Substances.

Names.	Cubic feet in lbs.	Cubic inch in lbs.
Cast iron	450.55	.2607
Wrought iron	486.65	.2816
Steel	489.8	.2834
Copper	555.	.32118
Lead	708.85	.41015
Brass	537.75	.3112
Tin	456.	.263
White pine	29.56	.0171
Salt water (sea)	64.3	.03721
Fresh water	62.5	.03616
Air	.07529	——
Steam	.03689	——

Cast Iron expands $\frac{1}{162000}$ of its length for one degree of heat; greatest change in the shade, in this climate $\frac{1}{1170}$ of its length; exposed to the sun's rays, $\frac{1}{1000}$; shrinks in cooling from $\frac{1}{85}$ to $\frac{1}{98}$ of its length; is crushed by a force of 93.000 lbs. upon a square inch; will bear, without permanent alteration, 15.300 lbs. upon a square inch, and an extension of $\frac{1}{1200}$ of its length. Weight of modulus of elasticity for a base of an inch square, 18,400,000 lbs.; height of modulus of elasticity, 5,750,000 feet.

Wrought Iron expands $\frac{1}{143000}$ of its length for one degree of heat; will bear, on a square inch, without permanent alteration, 17,800 lbs., and an extension in length of $\frac{1}{1400}$; cohesive force is diminished $\frac{1}{3000}$ by an increase of one degree of heat. Weight of modulus of elasticity for a base of an inch square, 24,920,000 lbs.; height of modulus of elasticity 7,550,000 feet.

Practical Receipts.

[The following Receipts are selected from "Ure's Dictionary," "Cooley's Cyclopedia," "Muspratt's Chemistry," and other valuable sources.]

JAPANNING AND VARNISHING.

JAPANNING is the art of covering bodies by grounds of opaque colors in varnish, which may be afterwards decorated by printing or gilding, or left in a plain state. It is also to be looked upon in another sense, as that of ornamenting coaches, snuff boxes, screens, &c. All surfaces to be japanned must be perfectly clean, and leather should be stretched on frames. Paper should be stiff for japanning.

The French prime all their japanned articles, the English do not. This priming is generally of common size. Those articles, that are primed thus, never endure as well as those that receive the japan coating on the first operation, and thus it is that those articles of japan work that are primed with size when they are used for some time, crack, and the coats of japan fly off in flakes.

A solution of strong isinglass size and honey, or sugar candy, makes a good japan varnish to cover water colors on gold grounds.

A pure white priming for japanning, for the cheap method, is made with parchment size, and one-third of isinglass, laid on very thin and smooth. It is the better for three coats, and when the last coat is dry, it is prepared to receive the painting or figures. Previous to the last coat, however, the work should be smoothly polished. When wood or leather is to be japanned, and no priming used, the best plan is to lay on two or three coats of varnish made of seed-lac and resin, two ounces each, dissolved in alcohol and strained through a cloth. This varnish should be put on in a warm place, and the work to be varnished should, if possible, be warm also, and all dampness should be avoided, to prevent the varnish from being chilled. When the work is prepared with the above composition and dry, it is fit for the proper japan to be laid on. If the ground is not to be white the best varnish now to be used is made of shellac, as it is the best vehicle for all kind of colors. This is made in the proportions of the best shellac, five ounces, made into powder, steeped in a quart of alcohol, and kept at a gentle heat for two or three days and shaken frequently, after which the solution must be filtered through a flannel bag, and kept in a well corked bottle for use. This varnish for hard japanning on *copper* or *tin* will stand for ever, unless fire or hammer be used to burn or beetle it off.

The color to be used with shellac varnish may be of any pigments whatever to give the desired shade, as this varnish will mix with tny color.

WHITE JAPAN GROUND.

To form a hard, perfect white ground is no easy matter, as the substances which are generally used to make the japan hard, have a tendency, by a number of coats, to look or become dull in brightness. One white ground is made by the following composition: white flake or lead washed over and ground up with a sixth of its weight of starch, then dried and mixed with the finest gum, ground up in parts of one ounce gum, to half an ounce of rectified turpentine mixed and ground thoroughly together. This is to be finely laid on the article to be japanned, dried, and then varnished with five or six coats of the following: two ounces of the whitest seed-lac to three ounces of gum-anima reduced to a fine powder and dissolved in a quart of alcohol. This lac must be carefully picked. For a softer varnish than this, a little turpentine should be added, and less of the gum. A very good varnish and not brittle, may be made by dissolving gum-anima in nut oil, boiling it gently as the gum is added, and giving the oil as much gum as it will take up. The ground of white varnish may of itself be made of this varnish, by giving two or three coats of it, but when used it should be diluted with pure turpentine. Although this varnish is not brittle it is liable to be indented with strokes, and it will not bear to be polished, but if well laid on it will not need polishing afterwards; it also takes some time to dry. Heat applied to all oils, however, darkens their color, and oil varnishes for white grow very yellow if not exposed to a full clear light.

GUM COPAL.

Copal varnish is one of the very finest varnishes for japanning purposes. It can be dissolved by linseed oil, rendered dry by adding some quicklime at a heat somewhat less than will boil or decompose the oil by it.

This solution, with the addition of a little turpentine, forms a very transparent varnish, which, when properly applied and slowly dried is very hard and durable. This varnish is applied to snuff boxes, tea boards and other utensils. It also preserves paintings and renders their surfaces capable of reflecting light more uniformly.

If powered copal be mixed in a mortar with camphor, it softens and becomes a coherent mass, and if camphor be added to alcohol it becomes an excellent solvent of copal by adding the copal well ground, and employing a tolerable degree of heat, having the vessel well corked which must have a long neck for the allowance of expansion, and the vessel must only be about one-fourth filled with the mixture. Copal can also be incorporated with turpentine, with one part of powdered copal to twelve parts of pure turpentine, subjected to the heat of a sand-bath for several days in a long necked mattress, shaking it frequently.

Copal is a good varnish for metals, such as *tin*; the varnish must be dried in an oven, each coat, and it can be colored with some substances, but alcohol varnish will mix with any coloring matter. For white japans or varnishes, we have already shown that fine chalk or white lead was used as a basis, and the varnishes coated over it.

To japan or varnish white leather, so that it may be elastic, is altogether a different work from varnishing or japanning wood or metal, or papier mache.

For white leather oil is the principal ingredient, as it is well known that chalk is extensively used to give white leather its pure color, or speaking more philosophically, its fair colorless whiteness. White leather having already the basis of white varnish, it should get a light coat of the pure varnish, before mentioned, and dried well *in the oven*, or a coat of the oil copal will answer very well. This being well dried, boiled nut oil nicely coated and successively dried, will make a most beautiful white varnish for leather, not liable to crack. This quality takes a long time to dry, and of course is more expensive. Coarse varnish may be made of boiled linseed oil, into which is added gradually the acetate of lead as a drier. This addition must be done very cautiously as the oil will be apt to foam over.

A better and more safe drying mixture than the mere acetate of lead, is, to dissolve the acetate of lead in a small quantity of water, neutralize the acid with the addition of pipe clay, evaporate the sediment to perfect dryness, and feed the oil when gently boiling gradually with it.

These *varnishes* or *japans*, as far as described, have only reference to white grounds.

There is some nice work to be observed, and there is much in applying the varnishes at the right time, knowing by the eye the proper moment when the mixture is perfect, or when to add any ingredient. These things require practice.

BLACK GROUNDS.

Black grounds for japans may be made by mixing ivory black with shellac varnish; or for coarse work, lamp black and the top coating of common seedlac varnish. A common black japan may be made by painting a piece of work with drying oil, (oil mixed with lead,) and putting the work into a stove, not too hot, but of such a degree, gradually raising the heat and keeping it up for a long time, so as not to burn the oil and make it blister. This process makes very fair japan and requires no polishing.

BLACK JAPAN.

Naples asphaltum fifty pounds, dark gum-amime eight pounds, use, add linsced oil twelve gallons, boil, add dark gum amber ten pounds, previously fused and boiled with linseed oil two gallons, add the driers, and proceed as last. *Used* for wood or metals.

BRUNSWICK BLACK.

1. Foreign asphaltum forty-five pounds, drying oil six gallons, litharge six pounds, boil as last, and thin with twenty five gallons of oil of turpentine. *Used* for ironwork. &c. 2. Black pitch and gas tar asphaltum, of each twenty-five pounds, boil gently for five hours, then add linseed oil eight gallons, litharge and red lead, of each ten pounds, boil as before, and thin with oil of turpentine twenty gallons. Inferior to the last, but cheaper.

BLUE JAPAN GROUNDS.

Blue japan gronuds may be formed of bright Prussian blue. The color may be mixed with shellac varnish, and brought to a polishing state by five or six coats of varnish of seed-lac. The varnish, however, is apt to give a greenish tinge to the blue, as the varnish has a yellowish tinge, and blue and yellow form a green. Whenever a light blue is desired, the purest varnish must always be used.

SCARLET JAPAN.

Ground vermilion may be used for this, but being so glaring it is not beautiful unless covered over with rose-pink or lake, which have a good effect when thus used. For a very bright crimson ground, safflower or Indian lake should be used, always dissolved in the alchohol of which the varnish is made. In place of this lake, carmine may be used, as it is more common. The top coat of varnish must always be of the white seed-lac, which has been before described, and as many coats given as will be thought proper; it is easy to judge of this.

YELLOW GROUNDS.

If turmeric be dissolved in the spirit of wine and strained through a cloth, and then mixed with pure seed-lac varnish, it makes a good yellow japan. Saffron will answer for the same purpose in the same way, but the brightest yellow ground is made by a primary coat of pure crome yellow, and coated successively with the varnish. Dutch pink is used for a kind of cheap yellow japan ground. If a little dragon's blood be added to the varnish for yellow japan, a most beautiful and rich salmon-colored varnish is the result, and by these two mixtures all the shades of flesh-colored japans are produced.

GREEN JAPAN GROUNDS.

A good green may be made by mixing Prussian blue along with the cromate of lead, or with turmeric, or orpiment (sulphuret of arsenic).or ochre, only the two should be ground together and dissolved in alcohol and applied as a ground, then coated with four or five coats of shellac varnish, in the manner already described. A very bright green is made by laying on a ground of Dutch metal, or leaf of gold, and then coating it over with distilled verdigris dissolved in alcohol, then the varnishes ou the top. This is a splendid green, brilliant and glowing.

ORANGE COLORED GROUNDS.

Orange grounds may be made of yellow mixed with vermillion or carmine, just as a bright or rather inferior color is wanted. The yellow should always be in quantity to make a good full-color, and the red added in proportion to the depth of shade. If there is not a good full body of yellow, the color will look watery, or bare, as it is technically termed.

PURPLE JAPAN GROUNDS.

This is made by a mixture of lake and Prussian blue or carmine, or for an inferior color vermilion, and treated as the foregoing. When the ground is laid on and perfectly dried, a fine coat of pure boilled nut oil then laid on and perfectly dried, is a good method to have a japan, not liable to crack. But a better plan is to use this oil in the varnish given, the first coat, after the ground is laid on, and which should contain considerable of pure terpentine. In every case where oil is used for any purpose for varnish, it is all the better if turpentine is mixed with it. Turpentine enables oils to mix with either alcohol or water. Alkalies have this property also.

BLACK JAPAN.

1. Asphaltum three ounces, boiled oil four quarts, burnt umber eight ounces. Mix by heat, and when cooling thin with turpentine. 2. Amber twelve ounces, asphaltum two ounces; fuse by heat, add boiled oil half a pint, resin two ounces; when cooling add sixteen ounces oil of turpentine. Both are used to varnish metals.

JAPAN BLACK FOR LEATHER.

1. Burnt umber four ounces, true asphaltum two ounces, boiled oil two quarts. Dissolve the asphaltum by heat in a little of the oil, add the burnt umber ground in oil, and the remainder of the oil, mix, cool and thin with turpentine. Flexible. 2. Shellac one part, wood naphtha four parts, dissolve, and color with lampblack. Inflexible.

TRANSPARENT JAPAN.

Oil of turpentine four ounces, oil of lavender three ounces, camphor one-half drachm, copal one ounce; dissolve. Used to japan *tin*, but quick copal varnish is mostly used instead.

JAPANNERS' COPAL VARNISH.

Pale African copal seven pounds, fuse, add clarified linseed oil one half gallon, boil for five minutes, remove it into he topen air, add boiling oil of turpentine three gallons, mix well, strain it into the cistern, and cover it up immediately. *Used* to varnish furniture, and by japanners, coacemakers, &c. *Dries* in 15 minutes, and may be polished as soon as hard.

TORTOISE SHELL JAPAN.

This varnish is prepared by taking of good linseed oil one gallon, and of umber half a pound, and boiling them together until the oil becomes very brown and thick, when they are strained through a cloth and boiled again until the composition is about the consistence of pitch, when it is fit for use. Having prepared this varnish, clean well the copper or iron plate or vessel that is to be varnished, (japanned,) and then lay vermillion, mixed with shellac varnish, or with drying oil, diluted with turpentine, very thinly on the places intended to imitate the clean parts of the tortoise shell. When the vermillion is dry brush over the whole with the above umber varnish diluted to a due consistence with turpentine, and when it is set and firm, it must be put into a stove and undergo a strong heat for a long time, even two weeks will not hurt it. This is the ground for those beautiful snuff boxed and tea boards which are so much admired, and those grounds can be decorated with all kinds of paintings that fancy may suggest, and the work is all the better to be finished in an annealing oven.

PAINTING JAPAN WORK.

The colors to be painted are tempered, generally, in oil, which should have at least one-fourth of its weight of gum sandarach, or mastic dissolved in it, and it should be well diluted with turpentine, that the colors may be laid on thin and evenly. In some instances it does well to put on water colors or grounds of gold, which a skilful hand can do and manage so as to make the work appear as if it was embossed. These water colors are best prepared by means of isinglass size, mixed with honey, or sugar candy. These colors when laid on must receive a number of upper coats of the varnish we have described before.

JAPANNING OLD TEA-TRAYS.

First clean them thoroughly with soap and water and a little rotten stone; then dry them by whiping and exposure at the fire. Now, get seme good copal varnish, mix with it some bronze powder, and apply with a brush to the denuded parts. After which set the tea-tray in an oven at a heat of 212° or 300° until the varnish is dry. Two coats will make it equal to new.

JAPAN FINISHING.

The finishing part of japanning lies in laying on and polishing the outer coats of varnish, which is necessary in all painted or simply ground colord japan work. When brightness and clearness are wanted, the white kind of varnish is necessary, for seed-lac varnish, which is the hardest and most tenacious, imparts a yellow tinge. A mixed varnish, we believe, is the best for this purpose, that is, for combining hardness and purity. Take then three ounces of seed-lac, picked very carefully from all sticks and dirt and washing it well with cold water, stirring it up, pouring it off, and continuing the process until the water runs off perfectly pure. Dry it and then reduce it to powder, and put it with a pint of alcohol into a bottle, of which it must occupy only two-thirds of its space. This mixture must be shaken well together and the bottle kept at a gentle heat (being corked) until the lac be dissolved. When this is the case, the clear must be poured off, and the remainder strained through a cloth, and all the clear, strained and poured, must be kept in a well stopped bottle. The manner of using this seed-lac varnish is the same as that before described, and a fine polishing varnish is made by mixing this with pure white varnish. The pieces of work to be varnished for finishing should be placed near a stove, or in a warm, dry room, and one coat should be perfectly dry before the other is applied. The varnish is applied by proper brushes, beginning at the middle, passing the stroke to one end and with the other stroke from the middle to the other end. Great skill is displayed in laying on these coats of varnish. If possible the skill of hand should never cross, or twice pass over in giving one coat. When one coat is dry another must be laid over it, and so on successively for a number of coats, so that the coating should be sufficiently thick to stand fully all the polishing, so as not to bare the surface of the colored work. When a sufficient number of coats are thus laid on, the work is fit to be polished, which, in common cases, is commenced with a rag dipped in finely powdered rotten stone, and towards the end of the rubbing a little oil should be used along with the powder, and when the work appears fine and glossy a little oil should be used alone to clean off the powder and give the work a still brighter hue. In very fine work, French whiting should be used, which should be washed in water to remove any sand that might be in it. Pumice stone ground to a very fine powder is used for the first part of polishing, and the finishing done with whiting. It is always best to dry the varnish of all japan work by heat. For wood work, heat must be sparingly used, but for metals the varnish should be dried in an oven, also for papier mache and leather. The metal will stand the greatest heat, and care must be taken not to darken by too high a temperature. When gold size is used in guilding for japan work, where it is desired not to have the gold shine, or appear burnished, the gold size should be used with a little of the spirits of turpentine and a little oil, but when a considerable degree of lustre is wanted without burnishing and the preparation necessary for it, a little of the size along with oil alone should be used.

VARNISHES,—MISCELLANEOUS.

Different substances are employed for making varnish, the object being to produce a liquid easily applied to the surface of cloth, paper or metal, which, when dry, will protect it with a fine skin. Gums and resins are the substances employed for making varnishes; they are dissolved either in turpentine, alcohol, or oil, in a close stone ware, glass or metal vessel, exposed to a low heat, as the case may require, or cold. The alcohol or turpentine dissolves the gum or resin, and holds them in solution, and after the application of the varnish, this mixture being mechanical, the moisture of the liquid evaporates, and the gum adheres to the article to which it is applied.

The choice of linseed oil is of peculiar consequence to the varnish-maker. Oil from fine full-grown ripe seed, when viewed in a vial, will appear limpid, pale, and brilliant; it is mellow and sweet to the taste, has very little smell, is specifically lighter than impure oil, and, when clarified, dries quickly and firmly, and does not materially change the color of the varnish when made, but appears limpid and brilliant.

The following are the chief Resins employed in the manufacture of Varnishes.

AMBER.

This resin is most distinguished for durability. It is usually of some shade of yellow, transparent, hard and moderately tough. Heated in air, it fuses at about 549° ; it burns with a clear flame, emitting a pleasant odor.

ANIME.

This is imported from the East Indies. The large, transparent, pale-yellow pieces, with vitreous fracture, are best suited for varnish. Inferior qualities are employed for manufacturing gold-size or japan-black. Although superior to amber in its capacity for drying, and equal in hardness, varnish made from anime deepens in color on exposure to air, and is very liable to crack. It is, however, much used for mixing with copal varnish.

BENZOIN.

This is a gum-resin but little used in varnishes, on account of its costliness.

COLOPHONY.

This resin is synonymous with arcanson and rosin. When the resinous juce of *Pinus Sylvestris* and other varities is distilled, colophony remains in the retort. Its dark color is due to the action of the fire. Dissolved in linseed oil, or in turpentine by the aid of heat, colophony forms a brilliant, hard, but brittle varnish.

COPAL.

This is a gum-resin of immense importance to the varnish-maker. It consists of several minor resins of different degrees of solubility. In durability, it is only second to amber. When made into varnish, the better sorts become lighter in color by exposure to air.

Copal is generally imported in large lumps about the size of potatoes. The clearest and palest are selected for what is called *body-gum ;* the second best forms *carriage-gum;* whilst the residue, freed from the many impurities with which it is associated, constitutes *worst quality*, fitted only for japan-black or gold-size.

In alcohol, copal is but little soluble ; but it is said to become more so by reducing it to a fine powder, and exposing it to atmospheric influences for twelve months. Boiling alcohol or spirit of turpentine, when poured upon *fused* copal, accomplishes its complete solution, provided the solvent be not added in too large proportions at a time. The addition of camphor also promotes the solubility of copal; so likewise does oil of rosemary.

DAMMARA.

This is a tasteless, inodorous, whitish resin, easily soluble in oils. It is not so hard as mastic, with which it forms a good admixture.

ELEMI.

This is a resin of a yellow color, semi-transparent, and of faint fragrance. Of the two resins which it contains, one is crystallizable and soluble in cold alcohol.

LAC.

This constitutes the basis of spirit-varnish. The resin is soluble in strong alcohol aided by heat. Its solution in ammonia may be used as a varnish, when the articles coated with it are not exposed more than an hour or two at a time to water.

MASTIC.

This is a soft resin of considerable lustre. The two sorts in commerce are, *in tears* and the *common mastic*; the former is the purer of the two. It consists of two resins, one of which is soluble in dilute alcohol. With oil of turpentine, it forms a very pale varnish, of great lustre, which flows readily, and works easily. Moreover, it can be readily removed by friction with the hand; hence its use for delicate work of every description.

SANDARACH.

This is a pale, odorous resin, less hard than lac, with which it is often associated as a spirit-varnish. It consists of three resins differing as to solubility in alcohol, either, and turpentine. It forms a good pale varnish for light-colered woods; when required to be polished, Venice turpentine is added to give it body.

Of the solvents of these various resins, little need be said. In the manufacture of varnishes, great care, as well as cleanliness, are required. The resins should be washed in hot water, to free them from particles of dust and dirt; they should be dried and assorted according to their color, reserving the lightest shades for the best kinds of varnish.

The *linseed-oil* should be as pale colored, and as well clarified as possible. New oil always contains mucilage, and more or less of foreign matters; as these prevent the regular absorption of oxygen, the oil requires preliminary treatment. The common plan is to boil it with litharge; but such *oil varnish* is inferior to that prepared with sulphate of lead.

The best method is to rub up linseed-oil with dry sulphate of lead, in sufficient quantity to form a milky mixture. After a week's exposure to the light, and frequent shaking, the mucus deposits with the sulphate of lead, and leaves the oil perfectly clear. The precipitated slime forms a compact membrane over the lead, hardening to such an extent that the clarified oil may be readily poured off.

TURPENTINE.

This is of very extensive use. The older it is, the more ozonized, the better it is. Turpentine varnishes dry much more readily than oil varnishes, are of a lighter color, more flexible and cheap. They are, however, neither so tough nor so durable.

ALCOHOL.

This is employed as the solvent of sandarach and of lac. The stronger, *cæteris paribus*, the better.

NAPHTHA AND METHYLAMED SPIRIT OF WINE.

These are used for the cheaper varnishes. Their smell is disagreeable. The former is, however, a better solvent of resins than alcohol.

SPIRIT VARNISHES.

These varnishes may be readily colored—*red*, by dragon's blood; *yellow*, by gamboge. If a colored varnish is required, clearly no account need be taken of the color of the resins. Lac varnish may be bleached by Mr. Lemming's process:—Dissolve five ounces of shellac in a quart of spirit of wine; boil for a few minutes with ten ounces of well-burnt and recently-heated animal charcoal, when a small quantity of the solution should be drawn off and filtered: if not colorless, a little more charcoal should be added. When all tinge is removed, press the liquor through silk, as linen absorbs more varnish; and afterwards filter it through fine blotting-paper. Dr. Hare proceeds as follows:—Dissolve in an iron kettle about one part of pearlash in about eight parts of water, add one part of shell or seed lac, and heat the whole to ebullition. When the lac is dissolved, cool the solution, and impregnate, it with chlorine gas till the lac is all precipitated. The precipitate is white, but the color deepens by washing and consolidation. Dissolved in alcohol, lac bleached by this process yields a varnish which is as free from color as any copal varnish.

One word in conclusion with reference to all spirit varnishes. A damp atmosphere is sufficient to occasion a milky deposit of resin, owing to the diluted spirit depositing a portion: in such case the varnish is said to be *chilled*.

ESSENCE VARNISHES.

They do not differ essentially in their manufacture from spirit varnishes. The polish produced by them is more durable, although they take a longer time to dry.

OIL VARNISHES.

The most durable and lustrous of varnishes are composed of a mixture of resin, oil, and spirit of turpentine. The oils most frequently employed are linseed and walnut; the resins chiefly copal and amber.

The drying powder of the oil having been increased by litharge, red-lead, or by sulphate of lead, and a judicious selection of copal having been made, it is necessary, according to Booth, to bear in mind the following precautions before proceeding to the manufacture of varnish:—1. That oil varnish is not a solution, but an intimate mixture of resin in boiled oil and spirit of turpentine. 2. That the resin must be completely fused previous to the addition of the boiled or prepared oil. 3. That the oil must be heated from 250° to 300°. 4. That the spirit of turpentine must be added gradually, and in a thin stream, while the mixture of oil and resin is still hot. 5. That the varnish be made in dry weather, otherwise moisture is abrorbed, and its transparency and drying quality impaired.

The heating vessel must be of copper, with a riveted and not a soldered bottom. To promote the admixture of the copal with the *hot* oil, the copal—carefully selected, and of nearly uniform fusibility—is *separately* heated with continuous stirring over a charcoal fire. Good management is required to prevent the copal from burning or becoming even high colored. When completely fused, the heated oil should be gradually poured in with constant stirring. The *exact* amount of oil required must be determined by experiment. If a drop upon a plate, on cooling, assumes such a consistency as to be penetrated by the nail without cracking, the mixture is complete; but if it cracks, more oil must be added.

The spirit of turpentine *previously heated* is added in a thin stream to the former mixture, care being taken to keep up the heat of all the parts.

LACKER.

This is used for wood or brass work, and is also a varnish. For brass, the proportions are half a pound of pale shell-lac to one gallon of spirit of wine. It is better prepared without the aid of heat, by simple and repeated agitation. It should then be left to clear itself, and separated from the thicker portions and from all impurities by decantation. As it darkens on exposure to light, the latter should be excluded. It need scarcely be said that the color will be also modified by that of the lac employed.

1. COPAL VARNISHES.

1. Oil of turpentine one pint, set the bottle in a water bath, and add in small portions at a time, three ounces of powdered copal that has been previously melted by a gentle heat, and dropped into water; in a few days decant the clear. *Dries* slowly, but is very pale and durable. *Used* for pictures, &c. 2. Pale hard copal two pounds; fuse, add hot drying oil one pint, boil as before directed, and thin with oil of turpentine three pints, or as much as sufficient. Very pale. *Dries* hard in 12 to 24 hours. 3. Clearest and palest African copal eight pounds; fuse, add hot and pale drying oil two gallons, boil till it strings strongly, cool a little, and thin with hot rectified oil of turpentine three gallons, and immediately strain into the store can. Very fine. Both the above are used for pictures. 4 Coarsely-powdered copal and glass, of each four ounces, alcohol of 90 per cent one pint, camphor one-half ounce; heat it in a water bath so that the bubbles may be counted as they rise, observing frequently to stir the mixture; when cold decant the clear. *Used* for pictures. 5. Copal melted and dropped into water three ounces, gum sandarach six ounces, mastic and Chio turpentine of each two and one-half ounces, powdered glass four ounces, alcohol of 85 per cent, one quart; dissolve by a gentle heat. *Used* for metal, chairs, &c.

All copal varnishes are hard and durable, though less so than those made of amber, but they have the advantage over the latter of being paler. They are applied on coaches, pictures, polished metal, wood, and other objects requiring good durable varnish.

2. COPAL VARNISH.

Hard copal, 300 parts! drying linseed or nut oil, from 125 to 250 parts; oil of turpentine, 500; these three substances are to be put into three separate vessels; the copal is to be fused by a somewhat sudden application of heat; the drying oil is to be heated to a temperature a little under ebullition, and is to be added by small portions at a time to the melted copal. When this combination is made, and the heat a little abated, the essence of turpentine, likewise previously heated, is to be introduced by degrees; some of the volatile oil will be dissipated at first, but more being added, the union will take place. Great care must be taken to prevent the turpentine vapor from catching fire, which might occasion serious accidents to the operator. When the varnish is made and has cooled down to about 130 degrees of Fah., it may be strained through a filter, to separate the impurities and undissolved copal. Almost all varnish makers think it indispensable to combine the drying oil with the copal before adding the oil of turpentine, but in this they are mistaken. Boiling oil of turpentine combines very readily with fused copal; and, in some cases, it would probably be preferable to commence the operation with it, adding it in successive small quantities. Indeed, the whitest copal varnish can be made only in this way; for if the drying oil has been heated to nearly its boiling point, it becomes colored, and darkens the varnish.

This varnish improves in clearness by keeping. Its consistence may be varied by varying the proportions of the ingredients within moderate limits. Good varnish, applied in summer, should become so dry in twenty-four hours that the dust will not stick to it nor receive an impression from the fingers. To render it sufficiently dry and hard for polishing, it must be subjected for several days to the heat of a stove.

3. COPAL VARNISHES.

1. Melt in an iron pan at a slow heat, copal gum powdered, eight parts, and add balsam copaiva, previously warmed, two parts. Then remove from the fire, and add spirits of turpentine, also warmed beforehand, ten parts, to give the necessary consistence. 2. Prepared gum copal ten parts, gum mastic two parts, finely powdered, are mixed with white turpentine and boiled linseed oil, of each one part, at a slow heat, and with spirits of turpentine twenty parts. 3. Prepared gum-copal ten parts, white turpentine two parts, dissolve in spirits of turpentine.

Gum-copal is *prepared* or made more soluble in spirits of turpentine, by melting the powdered crude gum, afterwards again powdering, and allowing to stand for some time loosely covered.

CABINET VARNISH.

Copal, fused, fourteen pounds; linseed oil, hot, one gallon; turpentine, hot, three gallons. Properly boiled, such a varnish will dry in ten minutes.

TABLE VARNISH.

Damma resin, one pound; spirits of turpentine, two pounds; camphor, two hundred grains. Digest the mixture for twenty-four hours. The decanted portion is fit for immediate use.

COMMON TABLE VARNISH.

Oil of turpentine, one pound; bees' wax, two ounces; colophony, one drachm.

COPAL VARNISH FOR INSIDE WORK.

1. Pounded and oxidized copal, twenty-four parts; spirit of turpentine, forty parts; camphor, one part.—2. *Flexible Copal Varnish.* Copal in powder, sixteen parts; camphor, two parts; oil of lavender, ninety parts.

Dissolve the camphor in the oil, heat the latter, and stir in the copal in successive portions until complete solution takes place. Thin with sufficient turpentine to make it of proper consistence.

BEST BODY COPAL VARNISH FOR COACH MAKERS, &C.

This is intended for the body parts of coaches and other similar vehicles, intended for polishing. Fuse eight lbs. of fine African gum copal, and two gallons of clarified oil, boil it very slowly for four or five hours, until quite stringy, mix with three gallons and a half of turpentine; strain off and pour it into a cistern. If this is too slow in drying, coach-makers, painters and varnish-makers have introduced to two pots of the preceding varnish, one made as follows: eight lbs. of fine pale gum-anime, two gallons of clarified oil and three and a half gallons of turpentine. To be boiled four hours.

COPAL POLISH.

Digest or shake finely powdered gum copal four parts, and gum camphor one part, with either to form a semi-fluid mass, and then digest with a sufficient quantity of alcohol.

WHITE SPIRIT VARNISH.

Sandarach, 250 parts; mastic, in tears, 64; elemi resin, 32; turpentine, 64; alcohol of 85 per cent, 1000 parts, by measure. The turpentine is to be added after the resins are dissolved. This is a brilliant varnish, but not so hard as to bear polishing.

WHITE HARD SPIRIT VARNISHES.

1. Gum sandarach five pounds, camphor one ounce, rectified spirit (65 over proof) two gallons, washed and dried coarsely-pounded glass two pounds; proceed as in making mastic varnish; when strained add one quart of very pale turpentine varnish. Very fine. 2. Picked mastic and coarsely-ground glass, of each, four ounces, sandarach and pale clear Venice turpentine, of each three ounces, alcohol two pounds; as last. 3. Gum sandarach one pound, clear Strasburg turpentine six ounces, rectified spirit (65 over proof) three pints: dissolve. 4. Mastic in tears two ounces, sandarach eight ounces, gum elemi one ounce, Strasburgh or Scio turpentine (genuine) four ounces, rectified spirit (65 over proof) one quart. *Used* on metals, &c. Polishes well.

WHITE VARNISH.

1. Tender copal seven and one-half ounces, camphor one ounce, alcohol of 95 per cent, one quart; dissolve, then add mastic two-ounces, Venice turpentine one ounce; dissolve and strain. Very white, drying, and capable of being polished when hard. *Used* for toys. 2. Sandarach eight ounces, mastic two ounces, Canada balsam four ounces, alcohol one quart. *Used* on paper, wood, or linen.

SOFT BRILLIANT VARNISH.

Sandarach six ounces, elemi (genuine) four ounces, anime one ounce, camphor one-half ounce, rectified spirit one quart; as before.

The above spirit varnishes are chiefly applied to objects of the toilette, as work-boxes, card-cases, &c., but are also suitable to other articles, whether of paper, wood, linen, or metal, that require a brilliant and quick-drying varnish. They mostly dry almost as soon as applied, and are usually hard enough to polish in 24 hours. Spirit varnishes are less durable and more liable to crack than oil varnishes.

BROWN HARD SPIRIT VARNISHES.

1. Sandarach four ounces' pale seed-lac, two ounces, elemi (true) one ounce, alcohol one quart; digest with agitation till dissolved, then add Venice turpentine two ounces. 2. Gum sandarach three pounds, shellac two pounds, rectified spirit, (65 over proof,) two gallons; dissolve, add turpentine varnish one quart; agitate well and strain. Very fine. 3. Seed-lac and yellow resin, of each one and one-half pounds, rectified spirit two gallons.

TO PREPARE A VARNISH FOR COATING METALS.

Digest one part of bruised copal in two parts of absolute alcohol; but as this varnish dries too quickly it is preferable to take one part of copal, one part of oil of rosemary, and two or three parts of absolute alcohol. This gives a clear varnish as limpid as water. It should be applied hot, and when dry it will be found hard and durable.

TO VARNISH ARTICLES OF IRON AND STEEL.

Dissolve 10 parts of clear grains of mastic, 5 parts of camphor, 15 parts of sandarach, and 5 of elemi, in a sufficient quantity of alcohol, and apply this varnish without heat. The articles will not only be preserved from rust, but the varnish will retain its transparency and the metallic brilliancy of the articles will not be obscured.

VARNISH FOR IRON WORK.

Dissolve, in about two lbs. of tar oil, half a pound of asphaltum, and a like quantity of pounded resin, mix hot in an iron kettle care being taken to prevent any contact with the flame. When cold the varnish is ready for use. This varnish is for out-door wood and iron work, not for japanning leather or cloth.

BLACK VARNISH FOR IRON WORK.

Asphaltum forty-eight pounds, fuse, add boiled oil ten gallons, red lead and litharge, of each seven pounds, dried and powdered white copperas three pounds, boil for two hours, then add dark gum amber (fused) eight pounds, hot linseed oil two gallons, boil for two hours longer, or till a little of the mass, when cooled, may be rolled into pills, then withdraw the heat, and afterwards thin down with oil of turpentine thirty gallons. *Used* for the iron-work of carriages, and other nice purposes.

BRONZE VARNISH FOR STATUARY.

Cut best hard soap fifty parts, into fine shavings, dissolve in boiling water two parts, to which add the solution of blue vitriol fifteen parts, in pure water sixty parts. Wash the copper-soap with water, dry it at a very slow heat, and dissolve it in spirits of turpentine.

AMBER VARNISHES.

1. Amber one pound, pale boiled oil ten ounces, turpentine one pint. Render the amber, placed in an iron pot, semi-liquid by heat; then add the oil, mix, remove it from the fire, and when cooled a little, stir in the turpentine. 2. To the amber, melted as above, add two ounces of shellac, and proceed as before.

This varnish is rather dark, but remarkably tough. The first form is the best. It is used for the same purposes as copal varnish, and forms an excellent article for covering wood, or any other substance not of a white or pale color. It dries well, and is very hard and durable.

AMBER VARNISH, BLACK.

Amber one pound, boiled oil one-half pint, powdered asphaltum six ounces, oil of turpentine one pint. Melt the amber, as before described, then add the asphaltum, previously mixed with the cold oil, and afterwards heated very hot, mix well, remove the vessel from the fire, and when cooled a little add the turpentine, also made warm.

Each of the above varnishes should be reduced to a proper consistence with more turpentine if required. The last form produces the *beautiful black varnish* used by the coachmakers. Some manufacturers omit the whole or part of the asphaltum, and use the same quantity of clear black rosin instead, in which case the color is brought up by lampblack reduced to an impalpable powder, or previously ground very fine with a little boiled oil. The varnish made in this way, lacks, however, that richness, brilliancy, and depth of blackness imparted by asphaltum.

AMBER VARNISHES.

1. (*Pale.*) Amber pale and transparent six pounds, fuse, add hot clarified linseed oil two gallons, boil till it strings strongly, cool a little, and add oil of turpentine four gallons. Pale as copal varnish; soon becomes very hard, and is the most durable of oil varnishes; but requires time before it is fit for polishing. When wanted to dry and harden quicker, "drying" oil may be substituted for linseed, or "driers" may be added during the boiling. 2. Amber one pound; melt, add Scio turpentine one-half pound, transparent white resin two ounces, hot linseed oil one pint, and afterwards oil of turpentine as much as sufficient; as above. Very tough. 3. (*Hard.*) Melted amber four ounces, hot boiled oil oue quart: as before. 4. (*Pale.*) Very pale and transparent amber four ounces, clarified lidseed oil and oil of turpentine, of each one pint; as before.

Amber varnish is suited for all purposes, where a very hard and durable oil varnish is required. The paler kind is superior to copal varnish, and is often mixed with the latter to increase its hardness and durability.

BLACK VARNISH.

Heat to boiling linseed oil varnish ten parts, with burnt umber two parts, and powdered asphaltum one part, and when cooled dilute with spirits of turpentine to the required consistence.

VARNISH FOR CERTAIN PARTS OF CARRIAGES.

Sandarach, 190 parts; pale shellac, 95; resin, 125; turpentine, 190; alcohol, at 85 per cent, 1000 parts, by measure.

COACH VARNISH.

Mix shellac sixteen parts, white turpentine three parts, lampblack sufficient quantity, and digest with alcohol ninety parts, oil of lavender four parts.

MAHOGANY VARNISH.

Sorted gum-anime eight pounds, clarified oil three gallons, litharge and powdered dried sugar of lead, of each one-fourth pound; boil till it strings well, then cool a little, thin with oil of turpentine five and one-half gallons, and strain.

VARNISH FOR CABINET MAKERS.

Pale shellac, 750 parts; mastic, 64; alcohol, of 90 per cent, 1000 parts by measure. The solution is made in the cold, with the aid of frequent stirring. It is always muddy, and is employed without being filtered. With the same resins and proof spirit a varnish is made for the bookbinders to do over their morocco leather.

CEMENT VARNISH FOR WATER-TIGHT LUTING.

White turpentine fourteen parts, shellac eighteen parts, resin six parts, digest with alcohol eighty parts.

THE VARNISH OF WATIN FOR GILDED ARTICLES.

Gum-lac, in grain, 125 parts; gamboge, 125; dragon's blood, 125; annotto, 125; saffron, 32. Each resin must be dissolved in 1000 parts by measure, of alcohol of 90 per cent; two separate tinctures must be made with the dragon's blood and annotto, in 1000 parts of such alcohol; and a proper proportion of each should be added to the varnish, according to the shade of golden color wanted.

CHEAP OAK VARNISH.

Clear pale resin three and one-half pounds, oil of turpentine one gallon; dissolve. It may be colored darker by adding a little fine lampblack.

VARNISH FOR WOOD-WORK.

Powdered gum sandarach eight parts, gum mastic two parts, seed-lac eight parts, and digest in a warm place for some days with alcohol twenty-four parts, and finally, dilute with sufficient alcohol to the required consistence.

DARK VARNISH FOR LIGHT WOOD-WORK.

Pound up and digest shellac sixteen parts, gum sandarach thirty-two parts, gum mastic (juniper eight parts, gum elemi eight parts, dragon's blood four parts, annotto one part, with white turpentine sixteen parts, and alcohol two hundred and fifty-six. Dilute with alcohol if required.

VARNISH FOR INSTRUMENTS.

Digest seed-lac one part, with alcohol seven parts, and filter.

VARNISH FOR THE WOOD TOYS OF SPA.

Tender capal, 75 parts; mastic, 12.5; Venice turpentine, 6.5; alcohol, of 95 per cent, 100 parts by measure; water ounces, for example, if the other parts be taken in ounces. The alcohol must be first made to act upon the copal, with the aid of a little oil of lavender or camphor, if thought fit; and the solution being passed through a linen cloth, the mastic must be intoduced. After it is dissolved, the Venice turpentine, previously melted in a water-bath, should be added; the lower the temperature at which these operations are carried on, the more beautiful will the varnish be. This varnish ought to be very white, very drying, and capable of being smoothed with pumice-stone and polished.

VARNISHES FOR FURNITURE.

The simplest, and perhaps the best, is the solution of shellac only, but many add gums sandarach, mastic, copal, arabic, benjamin, &c., from the idea that they contribute to the effect. Gum arabic is certainly never required if the solvent be pure, because it is insoluble in either rectified spirit or rectified wood naphtha, the menstrua employed in dissolving the gums. As spirit is seldom used on account of its expense, most of the following are mentioned as solutions in naphtha, but spirit can be substituted when thought proper.

1. Shellac one and a half pounds, naphtha one gallon; dissolve, and it is ready without filtering. 2. Shellac twelve ounces, copal three ounces, (or an equivalent of varnish); dissolve in one gallon of naphtha. 3. Shellac one and a half pounds, seed-lac and sandarach each founr ounces, mastic two ounces, rectified spirit one gallon; dissolve. 4. Shellac two pounds, benzoin four ounces, spirit one gallon. 5. Shellac ten ounces, seed-lac, sandarach, and copal varnish of each, six ounces, benzoin three ounces, naphtha one gallon.

To darken polish, benzoin and dragon's-blood are used, turmeric and other coloring matters are also added; and to make it lighter it is necessary to use bleached lac, though some endeavor to give this effect by adding oxalic acid to the ingredients, it, like gum arabic, is insoluble in good spirit or naphtha. For all ordinary purposes the first form is best and least troublesome, while its appearance is equal to any other.

TO FRENCH POLISH.

The wood must be placed level, and sand-papered until it is *quite smooth*, otherwise it will *not polish*. Then provide a rubber of cloth, list, or sponge, wrap it in a soft rag, so as to leave a handle at the back for your hand, shake the bottle against the rubber, and in the middle of the varnish on the rag place with your finger a little raw linseed oil. Now commence rubbing, in small circular strokes, and continue until the pores are filled, charging the rubber with varnish and oil as required, until the whole wood has had one coat. When dry repeat the process once or twice until the surface appears even and fine, between each coat using fine sandpaper to smooth down all irregularities. Lastly, use a clean rubber with a little strong alcohol only, which will remove the oil and the cloudiness it causes; when the work will be complete.

FURNITURE POLISHES.

New wood is often French-polished. Or the following may be tried:

Melt three or four pieces of sandarach, each the size of a walnut, add one pint of boiled oil, and boil together for one hour. While cooling add one drachm of venice turpentine, and if to thick a little oil of turpentine also. Apply this all over the furniture, and after some hours rub it off; rub the furniture daily, without applying fresh varnish, except about once in two months. Water does not injure this polish, and any stain or scratch may be again covered, which cannot be done with French-polish.

FURNITURE GLOSS.

To give a gloss to household furniture, various compositions are used, known as wax, polish, creams, pastes, oils, &c. The following are some of the forms used:

FURNITURE CREAM.

Bees-wax one pound, soap four ounces, pearlash two ounces, soft water one gallon; boil togethar until mixed.

FURNITURE OILS.

1. Acetic acid two drachms, oil of lavender one-half drachm, rectified spirit one drachm, linseed oil four ounces. 2. Linseed oil one pint, alkanet root two ounces; heat, strain, and add lac varnish one ounce. 3. Linseed oil one pint, rectified spirit two ounces, butter of antimony four ounces.

FURNITURE PASTES.

1. Bees-wax, spirit of turpentine, and linseed oil, equal parts; melt and cool. 2. Bees-wax four ounces, turpentine ten ounces, alkanet root to color; melt and strain. 3. Bees-wax one pound, linseed oil five ounces, alkanet root one-half ounce; melt, add five ounces of turpentine, strain and cool. 4. Bees-wax four ounces, resin one ounce, oil of turpentine two ounces, venetian red to color.

ETCHING VARNISHES.

1. White wax, two ounces; black and Burgundy pitch, of each one-half ounce; melt together, add by degrees powdered asphaltum two ounces, and boil till a drop taken out on a plate will break when cold by being bent double two or three times between the fingers; it must then be poured into warm water and made into small balls for use. 2. (*Hard Varnish.*) Linseed oil and mastic, of each four ounces; melt together. 3. (*Soft Varnish.*) Soft linseed oil, four ounces; gun benzoin and white wax, of each one-half ounce; boil to two-thirds.

VARNISH FOR ENGRAVINGS, MAPS, ECT.

Digest gum sandarach twenty parts, gum mastic eight parts, camphor one part, with alcohol forty-eight parts. The map or engraving must previously receive one or two coats of gelatine.

VARNISH TO FIX ENGRAVINGS OR LITHOGRAPHS ON WOOD.

For fixing engravings or lithographs upon wood, a varnish called mordant is usee in France, which differs from others chiefly in containing more Venice turpentine, to make it sticky; it consists of sandarach, 250 parts; mastic in tears, 64; rosin, 125; Venice turpentine, 250; alcohol, 1000 parts by measure.

VARNISHES FOR OIL PAINTINGS AND LITHOGRAPHS.

1. Dextrine 2 parts, alcohol 1 part, water 6 parts. 2. Varnish for drawings and lithographs: dextrine 2 parts, alcohol ½ part,

water 2 parts. These should be prepared previously with two or three coats of thin starch or rice boiled and strained through a cloth.

VARNISH FOR OIL PAINTINGS.

Digest at a slow heat gum sandarach two parts, gum mastic four parts, balsam copaiva two parts, white turpentine three parts, with spirits of turpentine four parts, alcohol (95 per cent) 50 56 parts.

BEAUTIFUL VARNISH FOR PAINTINGS AND PICTURES.

Honey, 1 pint; the whites of two dozen fresh hen's eggs; 1 ounce of good clean isinglass, 20 grains of hydrate of potassium ½ ounce of chloride of sodium; mix together over a gentle heat of 80 or 90 degrees Fah.; be careful not to let the mixture remain long enough to coagulate the albumen of the eggs; stir the mixture thoroughly then bottle. It is to be applied as follows: one table spoonful of the varnish added to half a table spoonful of good oil of turpentine, then spread on the picture as soon as mixed.

MILK OF WAX.

Milk of wax is a valuable varnish, which may be prepared as follows:—Melt in a porcelain capsule a certain quantity of white wax, and add to it, while in fusion, an equal quantity of spirit of wine, of sp. grav. 0·830; stir the mixture, and pour it upon a large porphyry slab. The granular mass is to be converted into a paste by the muller, with the addition, from time to time, of a little alcohol; and as soon as it appears to be smooth and homogeneous, water is to be introduced in small quantities successively, to the amount of four times the weight of the wax. This emulsion is to be then passed through canvas, in order to separate such particles as may be imperfectly incorporated. The milk of wax, thus prepared, may be spread with a smooth brush upon the surface of a painting, allowed to dry, and then fused by passing a hot iron (salamander) over its surface. When cold, it is to be rubbed with a linen cloth to bring out the luster. It is to the unchangeable quality of an encaustic of this nature, that the ancient paintings upon the walls of Herculaneum and Pompeii owe their freshness at the present day.

CRYSTAL VARNISHES.

1. Genuine pale Canada balsam and rectified oil of turpentine, equal parts; mix, place the bottle in warm water, agitate well, set it aside, in a moderately warm place, and in a week pour off the clear. *Used* for maps, prints, drawings, and other articles of paper, and also to prepare tracing paper, and to transfer engravings. 2. Mastic three ounces, alcohol one pint; dissolve. *Used* to fix pencil drawings.

ITALIAN VARNISHES.

1. Boil Scio turpentine till brittle, powder, and dissolve in oil of turpentine. 2. Canada balsam and clear white resin, of each six ounces, oil of turpentine one quart; dissolve. *Used* for prints, &c.

SIZE, OR VARNISH, FOR PRINTERS, ETC.

Best pale glue and white curd soap, of each 4 ounces; hot water 3 pints; dissolve, then add powdered alum 2 ounces. *Used* to size prints and pictures before coloring them.

MASTIC VARNISHES.

1. (*Fine.*) Very pale and picked gum mastic five pounds, glass pounded as small as barley, and well washed and dried two and one-half pounds, rectified turpentine two gallons; put them into a clean four gallon stone or tin bottle, bung down securely, and keep rolling it backwards and forwards pretty smartly on a counter or any other solid place for at least four hours; when, if the gum is all dissolved, the varnish may be decanted, strained through muslin into another bottle, and allowed to settle. It should be kept for six or nine months before use, as it thereby gets both tougher and clearer. 2. (*Second Quality.*) Mastic eight pounds, turpentine four gallons; dissolve by a gentle heat, and add pale turpentine varnish one-half gallon. 3. Gum mastic six ounces, oil of turpentine one quart; dissolve.

Mastic varnish is used for pictures, &c.; when good, it is tough, hard, brilliant, and colorless. Should it get "*chilled*," one pound of well-washed silicious sand should be made moderately hot, and added to each gallon, which must then be well agitated for five minutes, and afterwards allowed to settle.

INDIA-RUBBER VARNISHES.

1. Cut up one pound of India rubber into small pieces rnd diffuse in half a pound of sulphuric ether, which is done by digesting in a glass flask on a sand bath. Then add one pound pale linseed oil varnish, previously heated, and after settling, one pound of oil of turpentine, also heated beforehand. Filter, while yet warm, into bottles. Dries slowly.

2. Two ounces India rubber finely divided and digested in the same way, with a quarter of a pound of camphene, and half an ounce of naphtha or benzole. When dissolve add one ounce of copal varnish, which renders it more durable. Principally for gilding.

3. In a wide mouthed glass bottle, digest two ounces of India rubber in fine shavings, with one pound of oil of turpentine, during two days, without shaking, then stir up with a wooded spatula. Add another pound of oil of turpentine, and digest, with frequent agitation, until all is dissolved. Then mix a pound and a half of this solution with two pounds of very white copal-oil varnish, and a pound and a half of well boiled linseed oil, shake and digest in a sand bath, until they have united into a good varnish.—For morocco leather.

4. Four ounces India rubber in fine shavings are dissolved in a covered jar by means of a sand bath, in two pounds of crude ben-

zole, and then mixed with four pounds of hot linseed oil varnish, and a half pound of oil of turpentine. Dries very well.

5. *Flexible Varnish.*—Melt one pound of rosin, and add gradually half a pound of India rubber in very fine shavings, and stir until cold. Then heat again, slowly, add one pound of linseed oil varnish, heated, and filter.

6. *Another.*—Dissolve one pound of gum dammar, and a half pound of India rubber, in very small pieces, in one pound of oil of turpentine, by means of a water bath. Add one pound of hot oil varnish and filter.

7. India rubber in small pieces, washed and dried, are fused for three hours in a close vessel, on a gradually heated sand bath. On removing from the sand bath, open the vessel and stir for ten minutes, then close again, and repeat the fusion on the following day, until small globules appear on the surface. Strain through a wire sieve.

8. *Varnish for Water proof Goods.*—Let a quarter of a pound of India rubber, in small pieces, soften in a half pound of oil of turpentine, then add two pounds of boiled oil, and let the whole boil for two hours over a slow coal fire. When dissolved, add again six pounds of boiled linseed oil and one pound of litharge, and boil until an even liquid is obtained. It is applied warm.

9. *Gutta Percha Varnish.*—Clean a quarter of a pound of Gutta Percha in warm water from adhering impurities, dry well, dissolve in one pound of rectified rosin oil, and add two pounds of linseed oil varnish, boiling hot. Very suitable to prevent metals from oxidation.

BLACK VARNISH FOR HARNESS.

Digest shellac twelve parts, white turpentine five parts, gum sandarach two parts, lampblack one part, with spirits of turpentine four parts, alcohol ninety-six parts.

BOILED OIL OR LINSEED-OIL VARNISH.

Boil linseed oil sixty parts, with litharge two parts, and white vitriol one part, each finely powdered, until all water is evaporated. Then set by. Or, rub up borate of manganese four parts, with some of the oil, then add linseed oil three thousand parts, and heat to boiling.

DAMMAR VARNISH.

Gum dammar ten parts, gum sandarach five parts, gum mastic one part, digest at a low heat, occasionally shaking, with spirits of turpentine twenty parts. Finally, add more spirits of turpentine to give the consistence of syrup.

COMMON VARNISH.

Digest shellac one part, with alcohol seven or eight parts.

WATERPROOF VARNISHES.

Take one pound of flowers of sulphur and one gallon of linseed oil, and boil them together until they are thoroughly combined.

This forms a good varnish for waterproof textile fabrics. Another is made with four pounds oxyde of lead, two pounds of lampblack, five ounces of sulphur, and ten pounds of India rubber dissolved in turpentine. These substances, in such proportions, are boiled together until they are thoroughly combined. Coloring matters may be mixed with them. Twilled cotton may be rendered waterproof by the application of the oil sulphur varnish. It should be applied at two or three different times, and dried after each operation.

VARNISHES FOR BALLOONS, GAS BAGS, ETC.

1. India rubber in shavings one ounce; mineral naphtha two lbs.; digest at a gentle heat in a close vessel till dissolved, and strain. 2. Digest one pound of Indian rubber, cut small, in six pounds of oil of turpentine for 7 days, in a warm place. Put the mixture in a water bath, heat until thoroughly mixed, add one gallon of warm boiled drying oil, mix, and strain when cold. 3. Linseed oil one gallon; dried white copperas and sugar of lead, each three ounces; litharge eight ounces; boil with constant agitation till it strings well, then cool slowly and decant the clear. If too thick, thin it with quicker drying linseed oil.

GOLD VARNISH.

Digest shellace sixteen parts, gum sandarach, mastic, of each three parts, crocus one part, gum gamboge two parts, all bruised, with alcohol one hundred forty-four parts. Or, digest seed-lec, sandarach, mastic, of each eight parts, gamboge two parts, dragon's blood one part, white turpentine six parts, turmeric four parts, bruised, with alcohol one hundred twenty parts.

WAINSCOT VARNISH FOR HOUSE PAINTING AND JAPANNING.

Anime eight pounds; clarified linseed oil three gallons; litharge one-fourth pound; acetate of lead one-half pound; sulphate of copper one-fourth pound.

All these materials must be carefully but thoroughly boiled together untill the mixture becomes quite stringy, and then five and a half gallons of heated turpentine stirred in. It can be easily deepened in color by the addition of a little gold-size.

IRON WORK BLACK.

Put 48 lbs. asphaltum into an iron pot, and boil for 4 hours; during the first 2 hours, introduce 7 lbs. litharge, 3 lbs. dried copperas, and 10 galls. boiled; add 1-8th lb. run of dark gum, with 2 galls. hot oil. After pouring the oil and gum, continue the boiling 2 hours, or until it will roll into hard pills, like Japan. When cool, thin it off with 30 galls. turpentine, or until it is of proper consistence.

BLACK JAPAN VARNISH.

Bitumen, 2 ounces; lampblack, 1 ounce; Turkey umber, ½ ounce; acetate of lead ½ ounce; Venice turpentine, ½ ounce; boiled oil, 12 ounces. Melt the turpentine and oil together, carefully stiring in the rest of the ingredients, previously powdered. Simmet all together for ten minutes.

Tinware is japanned with Colored Copal Varnish, and then baked in an oven until the varnish becomes perfectly dry and hard. Varnishes may be colored with any of the pigments used in oil painting.

LEATHER VARNISH.

Durable leather varnish is composed of boiled linseed oil, in which a drier, such as litharge, has been boiled. It is colored with lampblack. This varnish, is used for making enamelled leather. Common leather varnish, which is used as a substitute for blacking, is made of thin lac-varnish colored with ivory black.

VARNISH FOR SMOOTH MOULDING PATTERNS.

Alcohol, 1 gall.; Shell Lac, 1 lb.; Lamp or Ivory Black, sufficient to color it.

FINE BLACK VARNISH FOR COACHES.

Melt in an Iron pot, Amber, 32 ozs.; Resin, 6 ozs.; Asphaltum, 6 ozs.; Drying Linseed Oil, 1 pt.; when partly cooled add Oil of Turpentine, warmed 1 pt.

LACKERS.

GOLD LACKER.

Put into a clean four gallon tin, one pound of ground turmeric, one and a half ounces of gamboge, three and a half pounds of powdered gum sandarach, three quarters of a pound of shellac, and two gallons of spirits of wine. When shaken, dissolved, and strained, add one pint of turpentine varnish, well mixed.

RED SPIRIT LACKER.

Made exactly as the gold lacker with these ingredients; two gallons of spirits of wine, one pound of dragon's blood, three pounds of Spanish annotto, three and a quarter pounds of gum sandarach, and two pints of turpentine.

PALE BRASS LACKER.

Two galls. spirits of wine; 3 oz. Cape aloes; cut small 1 ℔. fine pale shellac; 1 oz. gamboge, cut small; no turpentine;—varnish made exactly as before. But observe, that those who make lackers frequently want some paler and some darker; and sometimes inclining more to the particular tint of certain of the component ingredients. Therefore, if a 4 oz. phial of a strong solution of each ingredient be prepared, a lacker of any tint can be produced at any time.

LACKER FOR TIN.

Any good lacker laid upon tin gives it the appearance of copper or brass. It is made by coloring lac-varnish with turmeric to impart the color of brass to it, and with annotto, to give it the color of copper. If a tin plate is dipped into molten brass, the latter metal will adhere to it in a coat.

LACKER VARNISH.

A good lacker is made by coloring lac-varnish with turmeric and annotto. Add as much of these two coloring substances to the varnish as will give it the proper color; then squeeze the varnish through a cotton cloth, when it forms lacker.

DEEP GOLD COLORED LACKER.

Seed-lac three ounces, turmeric one ounce, dragon's blood one-fourth ounce, alcohol one pint; digest for a week, frequently shaking, decant and filter.

Lackers are used upon polished metals and wood to impart the appearance of gold. If yellow is required, use turmeric, aloes, saffron, or gamboge; for red, use annotto, or dragon's blood, to color. Turmeric, gamboge, and dragon's blood, generally afford a sufficient range of colors.

LACKERS FOR PICTURES, METAL, WOOD OR LEATHER.

1. Seed-lac eight ounces, alcohol one quart; digest in a close vessel in a warm situation for three or four days, then decant and strain. 2. Substitute lac bleached by chlorine for seed-lac. Both are very tough, hard, and durable; the last almost colorless.

DIRECTIONS FOR MAKING LACKER.

Mix the ingredients and let the vessel containing them stand in the sun, or in a place slightly warmed three or four days, shaking it frequently till the gum is dissolved, after which let it settle from twenty-four to forty-eight hours, when the clear liquor may be poured off for use. Pulverized glass is sometimes used in making lacker, to carry down the impurities.

LACKER FOR DIPPED BRASS.

Alcohol, proof specific gravity not less than 95-100ths, 2 galls.; seed-lac, 1 lb.; gum copal, 1 oz.; English saffron, 1 oz.; annotto, 1 oz.

LACKER FOR BRONZED BRASS.

To one pint of the above lacker, add, gamboge, 1 oz.; and after mixing it add an equal quantity of the first lacker.

DEEP GOLD COLORED LACKER.

Best alcohol, 40 ozs.; Spanish annotto, 8 grs.; turmeric, 2 drs.; shel-lac ½ oz.; red sanders, 12 grs.; when dissolved add spirits of turpentine, 30 drops.

GOLD COLORED LACKER, FOR BRASS NOT DIPPED.

Alcohol 4 galls. ; turmeric, 3 lbs. ; gamboge, 3 ozs. ; gum sandarach, 7 lbs. ; shellac, 1¼ lb. ; turpentine varnish, 1 pint.

GOLD COLORED LACKER FOR DIPPED BRASS.

Alcohol, 36 ozs. ; seed-lac, 6 ozs. ; amber, 2 ozs. ; gum gutta, 2 ozs. ; red sandal wood, 24 grs. ; dragon's blood, 60 grs. ; Oriental saffron, 36 grs, ; Pulverized glass, 4 ozs.

GOOD LACKER FOR BRASS.

Seed-lac, 6 ozs. ; amber or copal, 2 ozs. ; best alcohol, 4 galls. ; pulverized glass, 4 ozs. ; dragon's blood, 40 grs. ; extract of red sandal wood obtained by water, 30 grs.

LACKER FOR DIPPED BRASS.

Alcohol 12 galls. ; seed-lac, 9 lbs. ; turmeric, 1 lb. to a gallon of the above mixture , Spanish saffron, 4 ozs.

The saffron is to be added for bronze work.

GOOD LACKER.

Alcohol, 8 ozs.; gamboge, 1 oz.; shell lac, 3 ozs.; annotto, 1 oz.; solution of 3 ozs.; of seed lac in 1 pint of alcohol ; when dissolved add ¼ oz. venice turpentine, ¼ oz dragon's blood, will make it dark ; keep it in a warm place four or five days.

PALE LACKER FOR TIN PLATE.

Best alcohol, 8 ozs.; turmeric, 4 drs.; hay saffron, 2 scs.; dragon blood, scs.; red sanders, 1 scs.; shell lac, 1 oz.; gum sanderach, 2 drs.; gum mastic, 2 drs.; canada balsam, 2 drs.; when dissolved add spirits of turpentine, 80 drops.

RED LACKER FOR BRASS.

Alcohol, 8 galls.; dragon's blood, 4 lbs.; spanish annotto, 12 lbs.; gum sanderach, 13 lbs.; turpentine, 1 gall.

PALE LACKER FOR BRASS.

Alcohol, 2 galls.; cape aloes cut small, 3 ozs.; pale shellac, 1 lb.; gamboge, 1 oz.

BEST LACKER FOR BRASS.

Alcohol, 4 galls.; shell lac, 2 lbs.; amber gum, 1 lb.; copal, 20 ozs.; seed lac, 3 lbs.; saffron, to color; pulverized glass, 8 ozs.

COLOR FOR LACKER.

Alcohol, 1 qt.; annotto, 4 ozs.

LACKER FOR PILOSOPHICAL INSTRUMENTS.

Alcohol, 80 ozs.; gum gutta, 3 ozs.; gum sandarac, 8 ozs.; gum elemi, 8 ozs.; dragon's blood, 4 ozs; seed lac, 4 ozs.; terra merita, 3 ozs.; saffron, 8 grs.; pulverized glass, 12 ozs.

MISCELLANEOUS CEMENTS.

ARMENIAN OR DIAMOND CEMENT.

This article, so much esteemed for uniting pieces of broken glass, for repairing precious stones, and for cementing them to watch cases and other ornaments, is made by soaking isinglass in water until it becoms quite soft, and then mixing it with spirit in which a little gum mastic and ammoniacum have been dissolved.

The jewellers of Turkey, who are mostly Armenians, have a singular method of ornamenting watch cases, &c., with diamonds and other precious stones, by simply glueing or cementing them on. The stone is set in silver or gold, and the lower part of the metal made flat, or to correspond with the part to which it is to be fixed; it is then warmed gently, and has the glue applied, which is so very strong that the parts so cemented never separate; this glue, which will strongly unite bits of glass, and even polished steel, and may be applied to a variety of useful purposes, is thus made in Turkey:—Dissolve five or six bits of gum mastic, each the size of a large pea, in as much spirits of wine as will suffice to render it liquid; and in another vessel, dissolve as much isinglass, previously a little softened in water, (though none of the water must be used,) in French brandy or good rum, as will make a two-ounce vial of very strong glue, adding two small bits of gum albanum, or ammoniacum, which must be rubbed or ground till they are dissolved. Then mix the whole with a sufficient heat. Keep the glue in a vial closely stopped, and when it is to be used, set the vial in boiling water. Some persons have sold a composition under the name of Armenian cement, in England; but this composition is badly made; it is much too thin, and the quantity of mastic is much too small.

The following are good proportions: isinglass, soaked in water and dissolved in spirit, two ounces, (thick); dissolve in this ten grains of very pale gum ammoniac, (in tears,) by rubbing them together; then add six large tears of gum mastic, dissolved in the least possible quantity of rectified spirit.

Isinglass, dissolved in proof spirit, as above, three ounces; bottoms of mastic varnish (thick but clear) one and a half ounces; mix well.

When carefully made this cement resists moisture, and dries colorless. As usually met with, it is not only of very bad quality, but sold at exorbitant prices.

CEMENT FOR MENDING EARTHERN AND GLASS WARE.

1. Heat the article to be mended, a little above boiling water heat, then apply a thin coating of gum shellac, on both surfaces of the broken vessel, and when cold it will be as strong as it was

originally. 2. Dissolve gum shellac in alcohol, apply the solution, and bind the parts firmly together until the cement is perfectly dry.

CEMENT FOR STONEWARE.

Another cement in which an analogous substance, the curd or caseum of milk is employed, is made by boiling slices of skim-milk cheese into a gluey consistence in a great quantity of water, and then incorporating it with quicklime on a slab with a muller, or in a marble mortar. When this compound is applied warm to broken edges of stoneware, it unites them very firmly after it is cold

IRON-RUST CEMENT.

The iron-rust cement is made of from fifty to one hundred parts of iron borings, pounded and sifted, mixed with one part of sal-ammoniac, and when it is to be applied moistened with as much water as will give it a pasty consistency. Formerly flowers of sulphur were used, and much more sal-ammoniac in making this cement, but with decided disadvantage, as the union is effected by oxidizment, consequent expansion and solidification of the iron powder, and any hetrogeneous matter obstructs the effect. The best proportion of sal-ammoniac is, I believe, one per cent of the iron borings. Another composition of the same kind is made by mixing four parts of fine borings or filings of iron, two parts of potter's clay, and one part of pounded potsherds,and making them into a paste with salt and water. When this cement is allowed to concrete slowly on iron joints, it becomes very hard.

FOR MAKING ARCHITECTURAL ORNAMENTS IN RELIEF.

For making architectural ornaments in relief, a moulding composition is formed of chalk, glue, and paper paste. Even statues have been made with it, the paper aiding the cohesion of the mass.

Mastics of a resinous or bituminous nature, which must be softened or fused by heat, are the following:—

VARLEY'S MASTIC.

Mr. S. Varleys's consists of sixteen parts of whiting sifted and thoroughly dried by a red heat, adding when cold a melted mixture of sixteen parts of black rosin and one of bees'-wax, and stirring well during the cooling.

ELECTRICAL AND CHEMICAL APPARATUS CEMENT.

Electrical and chemical apparatus cement consists of 5 lbs. of rosin, 1 of bees'-wax, 1 of red ochre, and two table-spoonsful of Paris plaster, all melted together. A cheaper one for cementing voltaic plates into wooden troughs is made with 6 pounds of rosin, 1 pound of red ochre ½ of a pound of plaster of Paris, and ¼ of a a pound of linseed oil. The ochre and the plaster of Paris should be calcined beforehand, and added to the other ingredients in their melted state. The thinner stratum of cement that is interposed, the stronger, generally speaking, is the junction.

CEMENT FOR IRON TUBES, BOILERS, ETC.

Finely powdered iron sixty-six parts, sal-ammoniac one part, water a sufficient quantity to form into paste.

CEMENT FOR IVORY, MOTHER OF PEARL, ETC.

Dissolve one part of isinglass and two of white glue in thirty of water, strain and evaporate to six parts. Add one-thirtieth part of gum mastic, dissolved in half a part of alcohol, and one part of white zinc. When required for use, warm and shake up.

CEMENT FOR HOLES IN CASTINGS.

The best cement for this purpose is made by mixing one part of sulphur in powder, two parts of sal-ammoniac, and eighty parts of clean powdered iron turnings Sufficient water must be added to make it into a thick paste, which should be pressed into the holes or seams which are to be filled up. The ingredients composing this cement should be kept separate, and not mixed until required for use. It is to be applied cold, and the casting should not be used for two or three days afterwards.

CEMENT FOR COPPERSMITHS AND ENGINEERS.

Boiled linseed oil and red lead mixed together into a putty are often used by coppersmiths and engineers, to secure joints. The washers of leather or cloth are smeared with this mixture in a pasty state.

A CHEAP CEMENT.

Melted brimstone, either alone, or mixed with rosin and brick dust, forms a tolerably good and very cheap cement.

PLUMBER'S CEMENT.

Plumber's cement consists of black rosin one part, brick dust two parts, well incorporated by a melting heat.

CEMENT FOR BOTTLE-CORKS.

The bitumious or black cement for bottle-corks consists of pitch hardened by the addition of rosin and brick-dust.

CHINA CEMENT.

Take the curd of milk, dried and powdered, ten ounces; quicklime one ounce; camphor two drachms. Mix, and keep in closely stopped bottles. When used, a portion is to be mixed with a little water into a paste, to be applied quickly.

CEMENT FOR LEATHER.

A mixture of India-rubber and shell-lac varnish makes a very adhesive leather cement. A strong solution of common isinglass, with a little diluted alcohol added to it, makes an excellent cement for leather.

MARBLE CEMENT.

Take plaster of paris, and soak it in a saturated solution of alum, then bake the two in an oven, the same as gypsum is baked to make it plaster of paris; after which they are ground to powder. It is then used as wanted, being mixed up with water like plaster and applied. It sets into a very hard composition capable of taking a very high polish. It may be mixed with various coloring minerals to produce a cement of any color capable of imitating marble.

A GOOD CEMENT.

Shellac dissolved in alcohel, or in a solution of borax, forms a pretty good cement.

CEMENT FOR MARBLE WORKERS AND COPPERSMITHS.

White of egg alone, or mixed with finely sifted quicklime, will answer for uniting objects which are not exposed to moisture. The latter combination is very strong, and is much employed for joining pieces of spar and marble ornaments. A similar composition is used by coppersmiths to secure the edges and rivets of boilers; only bullock's blood is the albuminous matter used instead of white of egg.

TRANSPARENT CEMENT FOR GLASS.

Dissolve one part of India-rubber in 64 of chloroform, then add gum mastic in powder 14 to 24 parts, and digest for two days with frequent shaking. Apply with a camels-hair brush.

CEMENT TO MEND IRON POTS AND PANS.

Take two parts of sulphur, and one part, by weight, of fine black lead; put the sulphur in an old iron pan, holding it over the fire until it begins to melt, then add the lead; stir well until all is mixed and melted; then pour out on an iron plate, or smooth stone. When cool, break into small pieces. A sufficient quantity of this compound being placed upon the crack of the iron pot to be mended, can be soldered by a hot iron in the same way a tinsmith solders his sheets. If there is a small hole in the pot, drive a copper rivet in it and then solder over it with this cement.

CEMENT TO RENDER CISTERNS AND CASKS WATER TIGHT.

An excellent cement forresisting moisture is made by incorporating thoroughtly eight parts of melted glue, of the consistence used by carpenters, with four parts of linseed oil, boiled into varnish with litharge. This cement hardens is about forty-eight hours, and renders the joints of wooden cisterns and casks air and water tight. A compound of glue with one-fourth its weight of Venice turpentine, made as above, serves to cement glass, metal and wood, to one another. Fresh-made cheese curd and old skim-milk cheese, boiled in water to a slimy consistence, dissolved in a solution of bicarbonate of potash are said to form a good cement for glass and porcelain. The gluten of wheat, well prepared, is also a good cement. White of eggs, with flour and water well-mixed, and smeared over linen cloth, forms a ready lute for steam joints in small apparatus.

CEMENT FOR REPAIRING FRACTURED BODIES OF ALL KINDS.

White lead ground upon a slab with linseed oil varnish, and kept out of contact of air, affords a cement capable of repairing fractured bodies of all kinds. It requires a few weeks to harden. When stone or iron are to be cemented together, a compound of equal parts of sulphur with pitch answers very well.

CEMENT FOR CRACKS IN WOOD.

Make a paste of slacked lime one part, rye-meal two parts, with a sufficient quantity of linseed oil. Or, dissolve one part of glue in sixteen parts of water, and when almost cool stir in sawdust and prepared chalk a sufficient quantity. Or, oil-varnish thickened with a mixture of equal parts of white-lead, red-lead, litharge, and chalk.

CEMENT FOR JOINING METALS AND WOOD.

Melt rosin and stir in calcined plaster until reduced to a paste, to which add boiled oil a sufficient quantity, to bring it to the consistence of honey; apply warm. Or, melt rosin 180 parts, and stir in burnt umber 30, calcined plaster 15, and boiled oil 8 parts.

GAS FITTERS' CEMENT.

Mix together, resin four and one-half parts, wax one part, and venetian red three parts.

IMPERVIOUS CEMEMT FOR APPARATUS, CORKS, ETC.

Zinc-white rubbed up with copal varnish to fill up the indentures; when dry, to be covered with the same mass, somewhat thinner, and lastly with copal varnish alone.

CEMENT FOR FASTENING BRASS TO GLASS VESSELS.

Melt rosin 150 parts, wax 30, and add burnt ochre 30, and calcined plaster 2 parts. Apply warm.

CEMENT FOR FASTENING BLADES, FILES, ETC.

Shellac two parts, prepared chalk one, powdered and mixed. The opening for the blade is filled with this powder, the lower end of the iron heated and pressed in.

HYDRAULIC CEMENT PAINT.

If hydraulic cement be mixed with oil, it forms a first-rate anti-combustible and excellent water-proof paint for roofs of buildings, outhouses, walls, &c.

MISCELLANEOUS RECEIPTS.

PAINT FOR COATING WIRE WORK.

Boil good linseed oil with as much litharge as will make it of the consistency to be laid on with the brush; add lampblack at the rate of one part to every ten, by weight of the litharge; boil three hours over a gentle fire. The first coat should be thinner than the following coats.

RAZOR PASTE.

1. Levigated oxide of tin (prepared putty powder) 1 oz.; powdered oxalic acid 1-4 oz.; powdered gum 20 grs.; make it into a stiff paste with water, and evenly and thinly spread it over the strop. With very little friction, this paste gives a fine edge to the razor, and its efficiency is still further increased by moistening it.
2. Emery reduced to an impalpable powder 2 parts; spermaceti ointment 1 part; mix together, and rub it over the strop.
3. Jewellers' rouge, blacklead, and suet, equal parts; mix.

CUTTING GLASS.

To cut bottles, shades, or other glass vessels neatly, heat a rod of iron to redness, and having filled your vessal the exact height you wish it to be cut, with oil of any kind, you proceed very gradually to dip the red hot iron into the oil, which, heating all along the surface, suddenly the glass chips and cracks right round, when you can lift off the upper portion clean by the surface of the oil.

PREPARED LIQUID GLUE.

Take of best white glue 16 ounces; white lead, dry, 4 ounces; rain water 2 pints; alcohol 4 ounces. With constant stirring dissolve the glue and lead in the water by means of a water-bath. Add the alcohol, and continue the heat for a few minutes. Lastly pour into bottles while it is hot.

LIQUID GLUES.

Dissolve 33 parts of best (Buffalo) glue on the steam bath in a porcelain vessel, in 36 parts of water. Then add gradually stirring constantly, 3 parts of aqua fortis, or as much as is suffcient to prevent the glue from hardening when cool. Or dissolve one part of powdered alum in 120 of water, add 120 parts of glue, 10 of acetic acid and 40 of alcohol, and digest.

MARINE GLUE.

Dissolve 4 parts of india rubber in 34 parts of coal tar naphtha —aiding the solution with heat and agitation, add to it 64 parts of powdered shellac, which must be heated in the mixture, till the whole is dissolved. While the mixture is hot it is poured upon metal plates in sheets like leather. When required for use, it is heated in a pot, till soft, and then applied with a brush to the surfaces to be joined. Two pieces of wood joined with this glue can scarcely be sundered.

DEXTRINE, OR BRITISH GUM.

Dry potato-starch heated from 300° to 600° until it becomes brown, soluble in cold water, and ceases to turn blue with iodine. *Used* by calico printers and others, instead of gum arabic.

A LIQUID GLUE THAT KEEPS FOR YEARS.

Dissolve 2 pounds good glue in 2 1-9 pints hot water; add gradually, 7 oz. nitric acid, and mix well.

SEALING-WAX FOR FRUIT-CANS.

Beeswax, ½ oz.; English vermillion, 1½ ozs.; gum shellac, 2½ ozs.; rosin, 8 ozs. Take some cheap iron vessel that you can always keep for the purpose, and put in the rosin and melt it, and stir in the vermillion. Then add the shellac, slowly, and stir that in, and afterward the beeswax. When wanted for use at any after time, set it upon a slow fire and melt it so you can dip bottle-nozzles, in. For any purpose, such as an application to trees. where you want it tougher than the above preparation will make it, add a little more beeswax, and leave out the vermillion.

If the vermillion is left out in the above, the wax will be all the better for it, as it is merely used for coloring purposes.

FUSIBLE METAL.

1. Bismuth 8 parts; lead 5 parts; tin 3 parts; melt together Melts below 212 degrees Fahr. 2. Bismuth 2 parts; lead 5 parts; tin 3 parts. Melts in boiling water. 3. Lead 3 parts; tin 2 parts; bismuth 5 parts; mix. Melts at 197 deg. Fahr.

Remarks. The above are used to make toy-spoons, to surprise children by their melting in hot liquors; and to form pencils for writing on asses' skin, or paper prepared by rubbing burnt hartshorn into it.

METALLIC CEMENT.

M. Greshiem states that an alloy of copper and mercury, prepared as follows, is capable of attaching itself firmly to the surfaces of metal, glass, and porcelain. From twenty to thirty parts of finely divided copper, obtained by the reduction of oxide of copper with hydrogen, or by precipitation from solution of its sulphate with zinc, are made into a paste with oil of vitrol and seventy parts of mercury added, the whole being well triturated. When the amalgamation is complete, the acid is removed by washing with boiling water, and the compound allowed to cool. In ten or twelve hours, it becomes sufficiently hard to receive a brilliant polish, and to scratch the surface of tin or gold. By heat it assumes the consistence of wax; and, as it does not contract on cooling, M. Greshiem recommends its use by dentists for stopping teeth.

ARTIFICIAL GOLD.

This is a new metallic alloy which is now very extensively used in France as a substitute for gold. Pure copper 100 parts, zinc, or preferably tin 17 parts, magnesia 6 parts, sal ammoniac 3-6 parts, quick lime 1-8 parts, tartar of commerce 9 parts, are mixed as follows: The copper is first melted, then the magnesia, sal ammoniac, lime, and tartar, are then added, separately and by degrees, in the form of powder; the whole is now briskly stirred for about half an hour, so as to mix thoroughly; and then the zinc is added in small grains by throwing it on the surface and stirring till it is entirely fused; the crucible is then covered and the fusion maintained for about 35 minutes. The surface is then skimmed and the alloy is ready for casting.

It has a fine grain, is malleable and takes a splendid polish. It does not corrode readily, and for many purposes is an excellent substitute for gold. When tarnished, its brilliancy can be restored by a little acidulated water. If tin be employed instead of zinc the alloy will be more brilliant. It is very much used in France, and must ultimately attain equal popularity here.

OR-MOLU.

The or-molu of the brass founder, popularly known as an imitation of red gold, is extensively used by the French workmen in metals. It is generally found in combination with grate and stove work. It is composed of a greater portion of copper and less zinc than ordinary brass, is cleaned readily by means of acid, and is burnished with facility. To give this material the rich appearance, it is not unfrequently brightened up after "dipping" (that is cleaning in acid) by means of a scratch brush (a brush made of fine brass wire), the action of which helps to produce a very brilliant gold-like surface. It is protected from tarnish by the application of lacker.

BLANCHED COPPER.

Fuse 8 ounces of copper and ½ ounce of neutral arsenical salt with a flux made of calcined borax, charcoal dust and powdered glass.

BROWNING GUN BARRELS.

The tincture of iodine diluted with one-half its bulk of water, is a superior liquid for browning gun barrels.

SILVERING POWDER FOR COATING COPPER.

Nitrate of silver 30 grains, common salt 30 grains, cream of tartar 3½ drachms; mix, moisten with water, and apply.

ALLOY FOR JOURNAL BOXES.

The best alloy for journal boxes is composed of copper, 24 lbs.; tin, 24 lbs.; and antimony, 8 lb. Melt the copper first, then add the tin, and lastly the antimony. It should be first run into ingots, then melted and cast in the form required for the boxes.

ALLOY FOR BELLS OF CLOCKS.

The bells of the *pendules*, or ornamental clocks, made in Paris, are composed of copper 72.00, tin 26.56, iron 1.44, in 100 parts.

AN ALLOY FOR TOOLS.

An alloy of 1000 parts of copper and 14 of tin is said to furnish tools, which hardened and sharpened in the manner of the ancients, afford an edge nearly equal to that of steel.

ALLOY FOR CYMBALS AND GONGS.

An alloy for cymbals and gongs is made of 100 parts of copper with about 25 of tin. To give this compound the sonorous property in the highest degree, the piece should be ignited after it is cast, and then plunged immediately into cold water

SOLDER FOR STEEL JOINTS.

Silver 19 pennyweights, copper 1 pennyweight, brass 2 pennyweights. Melt under a coat of charcoal dust.

SOFT GOLD SOLDER.

Is composed of four parts gold, one of silver, and one of copper. It can be made softer by adding brass, but the solder becomes more liable to oxidize.

FILES.

Allow dull files to lay in diluted sulphuric acid until they are bit deep enough.

TO PREVENT RUSTING.

Boiled linseed oil will keep polished tools from rusting if it is allowed to dry on them. Common sperm oil will prevent them from rusting for a short period. A coat of copal varnish is frequently applied to polished tools exposed to the weather.

TO GALVANIZE.

Take a solution of nitro-muriate of gold (gold dissolved in a mixture of aqpafortis and muriatic acid) and add to a gill of it a pint of ether or alcohol, then immerse your copper chain in it for about 15 minutes, when it will be coated with a film of gald. The copper must be perfectly clean and free from oxyd, grease, or dirt, or it will not take on the gold.

YELLOW BRASS, FOR TURNING.—(*Common article.*)

Copper, 20 lbs.; zinc, 10 lbs.; lead from 1 to 5 ozs. Put in the lead last before pouring off.

RED BRASS, FOR TURNING.

Copper, 24 lbs.; zinc, 5 lbs.; lead, 8 ozs. Put in the lead last before pouring off.

RED BRASS, FREE, FOR TURNING.

Copper, 160 lbs.; zinc, 50 lbs.; lead, 10 lbs.; antimony, 44 ozs.

ANOTHER BRASS, FOR TURNING.

Copper, 32 lbs.; zinc, 10 lbs.; lead, 1 lb.

BEST RED BRASS, FOR FINE CASTINGS.

Copper, 24 lbs.; zinc, 5 lbs.; bismuth, 1 oz. Put in the bismuth last before pouring off.

BRONZE METAL.

Copper, 7 lbs.; zinc, 3 lbs.; tin, 2 lbs.

BRONZE METAL.

Copper, 1 lb.; zinc, 12 lbs.; tin, 8 lbs.

BELL METAL, FOR LARGE BELLS.

Copper, 100 lbs.; tin from 20 to 25 lbs.

BELL METAL, FOR SMALL BELLS.

Copper, 3 lbs.; tin, 1 lb.

COCK METAL.

Copper, 20 lbs.; lead, 8 lbs.; litharge, 1 oz.; antimony, 3 ozs.

BRITANNIA.

HARDENING FOR BRITANNIA.

To be mixed separately from the other ingredients. Copper, 2 lbs.; tin, 1 lb.

GOOD BRITANNIA METAL.

Tin, 150 lbs.; copper, 3 lbs.; antimony, 10 lbs.

BRITANNIA METAL, 2D QUALITY.

Tin, 140 lbs.; copper, 3 lbs.; antimony, 9 lbs.

BRITANNIA METAL, FOR CASTING

Tin, 210 lbs.; copper, 4 lbs.; antimony, 12 lbs.

BRITANNIA METAL, FOR SPINNING.

Tin, 100 lbs.; Britannia hardening, 4 lbs.; antimony, 4 lbs

BRITANNIA METAL, FOR REGISTERS.

Tin, 100 lbs.; hardening, 8 lbs.; antimony, 8 lbs.

BEST BRITANNIA FOR SPOUTS.

Tin, 140 lbs.; copper, 3 lbs.; antimony, 6 lbs.

BEST BRITANNIA FOR SPOONS.

Tin, 100 lbs.; hardening, 5 lbs.; antimony, 10 lbs.

BEST BRITANNIA, FOR HANDLES.

Tin, 140 lbs.; copper, 2 lbs.; antimony, 5 lbs.

BEST BRITANNIA, FOR LAMPS, PILLERS, AND SPOUTS.

Tin, 300 lbs.; copper, 4 lbs.; antimony, 15 lbs.

CASTING.

Tin, 100 lbs.; hardening, 5 lbs.; antimony, 5 lbs.

LINING METAL, FOR BOXES OF RAILWAY CARS.

Mix tin, 24 lbs.; copper, 4 lbs.; antimony, 8 lbs. (for a hardening); then add tin, 72 lbs.

FINE SILVER COLORED METAL.

Tin, 100 lbs.; antimony, 8 lbs.; copper, 4 lbs.; bismuth, 1 lb.

GERMAN SILVER, FIRST QUALITY FOR CASTING.

Copper, 50 lbs.; zinc, 25 lbs.; nickel, 25 lbs.

GERMAN SILVER, SECOND QUALITY FOR CASTING.

Copper, 50 lbs.; zinc, 20 lbs.; nickel, (best pulverized,) 10 lbs.

GERMAN SILVER, FOR ROLLING.

Copper, 60 lbs.; zinc, 20 lbs.; nickel, 25 lbs.

GERMAN SILVER, FOR BELLS AND OTHER CASTINGS.

Copper, 60 lbs.; zinc, 20 lbs.; nickel, 20 lbs.; lead, 3 lbs.; iron, (that of tin plate being best,) 2 lbs.

IMITATION OF SILVER.

Tin, 3 ozs.; copper, 4 lbs.

PINCHBECK.

Copper, 5 lbs.; zinc, 1 lb.

TOMBAC.

Copper, 16 lbs.; tin, 1 lb.; zinc, 1 lb.

RED TOMBAC.

Copper, 10 lbs.; zinc, 1 lb.

BRITANNIA METAL.

Brass, 4; tin, 4 parts; when fused, add bismuth, 4; and antimony, 4 parts. This composition is added at discretion to melted tin.

HARD WHITE METAL.

Sheet brass, 32 ozs.; lead, 2 ozs.; tin, 2 ozs.; zinc, 1 oz.

METAL FOR TAKING IMPRESSIONS.

Lead, 3 lbs.; tin, 2 lbs.; bismuth 5 lbs.

SPANISH TUTANIA.

Iron or steel, 8 ozs.; antimony, 16 ozs.; nitre, 3 ozs. Melt and harden 8 ozs. tin with 1 oz. of the above compound.

ANOTHER TUTANIA.

Antimony, 4 ozs.; arsenic, 1 oz.; tin, 2 lbs.

FUSIBLE ALLOY, WHICH MELTS IN BOILING WATER.

Bismuth, 8 ozs.; tin, 3 ozs.; lead, 5 ozs.

FUSIBLE ALLOY, FOR SIVERING GLASS.

Tin, 6 ozs.; lead, 10 ozs.; bismuth, 21 ozs.; mercury, a small quantity.

SOLDERS.

SOLDER FOR GOLD.

Gold, 6 pwts.; silver, 1 pwt.; copper, 2 pwts.

SOLDER FOR SILVER, FOR THE USE OF JEWELLER'S.

Fine silver, 19 pwts.; copper, 1 pwt.; sheet brass, 10 pwts.

WHITE SOLDER, FOR SILVER.

Silver, 1 oz.; tin, 1 oz.

WHITE SOLDER, FOR RAISED BRITANNIA WARE.

Tin, 100 lbs., copper, 3 ozs.; to make it free, add lead, 3 ozs.

BEST SOFT SOLDER, FOR CAST BRITANNIA WARE.

Tin, 8 lbs.; lead, 5 lbs.

YELLOW SOLDER, FOR BRASS, OR COPPER.

Copper, 1 lb.; zinc, 1 lb.

YELLOW SOLDER, FOR BRASS OR COPPER.

(Stronger than the last.) Copper, 32 lbs.; zinc, 29 lbs.; tin 1 lb.

SOLDER, FOR COPPER.

Copper, 10 lbs.; zinc, 9 lbs.

BLACK SOLDER.

Copper, 2 lbs.; zinc, 3 lbs.; tin, 2 ozs.

BLACK SOLDER.

Sheet brass, 20 lbs.; tin, 6 lbs.; zinc, 1 lb.

SILVER SOLDER, FOR PLATED METAL.

Fine silver, 1 oz.; brass, 10 pwts.

PLUMBER'S SOLDER.

Lead, 2; tin, 1 part.

TINMAN'S SOLDER.

Lead, 1; tin, 1 part.

PEWTERER'S SOLDER.

Tin, 2; lead, 1 part.

HARD SODDER

Copper, 2; zinc, 1 part

YELLOW DIPPING METAL.

Copper, 32 lbs.; zinc, 2 lbs.; soft solder, 2½ ozs.

QUICK BRIGHT DIPPING ACID, FOR BRASS WHICH HAS BEEN ORMOLOUD.

Sulphuric acid 1 gall.; nitric acid, 1 gall.

DIPPING ACID.

Sulphuric acid, 12 lbs.; nitric acid, 1 pint; nitre, 4 lbs.; soot, 2 handfuls; brimstone, 2 ozs. Pulverize the brimstone and soak it in water an hour. Add the nitric acid last.

GOOD DIPPING ACID, FOR CAST BRASS.

Sulphuric acid, 1 qt., nitre, 1 qt.; water, 1 qt. A little muriatic acid may be added or omitted.

DIPPING ACID.

Sulphuric acid, 4 galls.; nitric acid, 2 galls.; saturated solution of sulphate of iron (copperas), 1 pint; solution of suphate of copper, 1 qt.

ORMOLU DIPPING ACID, FOR SHEET BRASS.

Sulphuric acid, 2 galls.; nitric acid, 1 pt.; muriatic acid 1 pt.; water, 1 pt.; nitre, 12 lbs. Put in the muriatic acid last, a little at a time and stir the mixture with a stick.

ORMOLU DIPPING ACID, FOR SHEET OR CAST BRASS.

Sulphuric acid, 1 gall.; sal ammoniac, 1 oz.; sulphur, (in flour,) 1 oz.; blue vitriol, 1 oz.; saturated solution of zinc in nitric acid, mixed with an equal quantity of sulphuric acid, 1 gall.

TO PREPARE BRASS WORK FOR ORMOLU DIPPING.

If the work is oily, boil it in lye; and if it is finished work, filed or turned, dip it in old acid, and it is then ready to be ormeloed;

but if it is unfinished, and free from oil, pickle it in strong sulphuric acid, dip in pure nitric acid, and then in the old acid, after which it will be ready for ormeloing.

TO REPAIR OLD NITRIC ACID ORMOLU DIPS.

If the work after dipping appears coarse and spotted, add vitriol till it answers the purpose. If the work after dipping appears too smooth, add muriatic acid and nitre till it gives the right appearance.

The other ormolu dips should be repaired according to the receipts, putting in the proper ingredients to strengthen them They should not be allowed to settle, but should be stirred often while using.

VINEGAR BRONZE FOR BRASS.

Vinegar, 10 galls. ; blue vitriol, 3 lbs. ; muriatic acid, 3 lbs. ; corrosive sublimate, 4 grs. ; sal ammonia, 2 lbs. ; alum, 8 ozs.

BROWN BRONZE DIP.

Iron scales, 1 lb. ; arsenic, 1 oz. muriatic acid, 1 lb. ; zinc, (solid,) 1 oz. Let the zinc be kept in only while it is in use.

GREEN BRONZE DIP.

Wine vinegar, 2 qts. ; verditer green, 2 ozs. ; sal ammoniac, 1 oz. ; salt, 2 ozs. ; alum, ¼ oz. ; French berries, 8 ozs. ; boil the ingredients together.

AQUAFORTIS BRONZE DIP.

Nitric acid, 8 ozs. ; muriatic acid, 1 qt. ; sal ammoniac, 2 ozs. ; alum, 1 oz. ; salt, 2 ozs. ; water, 2 galls. Add the salt after boiling the other ingredients, and use it hot.

OLIVE BRONZE DIP, FOR BRASS.

Nitric acid, 3 ozs ; muriatic acid, 2 ozs ; add titanium or palladium ; when the metal is dissolved add 2 galls. pure soft water to each pint of the solution.

BROWN BRONZE PAINT FOR COPPER VESSELS.

Tincture of steel, 4 ozs. ; spirits of nitre, 4 ozs. ; essence of dendi, 4 ozs. ; blue vitriol, 1 oz. ; water ½ pint. Mix in a bottle. Apply it with a fine brush, the vessel being full of boiling water varnish after the application of the bronze.

BRONZE FOR ALL KINDS OF METAL.

Muriate of ammonia (sal amoniac), 4 drs. ; oxalic acid, 1 dr. ; vinegar, 1 pint. Dissolve the oxalic acid first. Let the work be clean. Put on the bronze with a brush, repeating the operation as many times as may be necessary.

BRONZE PAINT FOR IRON OR BRASS.

Chrome green, 2 lbs. ; ivory black, 1 oz. ; chrome yellow, 1 oz. ; good japan, 1 gill ; grind all together and mix with linseed oil.

TO BRONZE GUN BARRELS.

Dilute nitric acid with water and rub the gun-barrels with it; lay them by for a few days, then rub them with oil and polish them with bees-wax.

SILVERING BY HEAT.

Dissolve 1 oz. of silver in nitric acid; add a small quantity of salt; then wash it and add sal ammoniac, or 6 ozs. of salt and white vitriol; also ½ oz. of corrosive sublimate, rub them together till they form a paste, rub the piece which is to be silvered with the paste, heat it till the silver runs, after which dip it in a weak vitriol pickle to clean it.

MIXTURE FOR SILVERING.

Dissolve 2 ozs. of silver with 3 grains of corrosive sublimate; add tartaric acid, 4 lbs.; salt, 8 qts.

SEPARATE SILVER FROM COPPER.

Mix sulphuric acid 1 part; nitric acid, 1 part; water, 1 part boil the metal in the mixture till it is dissolved, and throw in a little salt to cause the silver to subside.

SOLVENT FOR GOLD.

Mix equal quantities of nitric and muriatic acids.

CHINESE WHITE COPPER.

Copper, 40.4; nickel, 31.6; zinc, 25.4; iron, 2.6 parts.

MANHEIM GOLD.

Copper, 3; zinc, 1 part and a small quantity of tin.

ALLOY OF THF STANDARD MEASURES USED BY THE BRITISH GOVERMENT

Copper 576; tin, 59; and brass, 48 parts.

BATH METAL.

Brass, 32; and zinc, 9 parts.

SPECULUM METAL.

Copper, 6; tin, 2; and arsenic, 1 part or, copper, 7; zinc, 3; and tin, 4 parts.

BLANCHED COPPER.

Copper, 3; and arsenic, ½ part.

COMMON PEWTER.

Tin, 4; Lead, 1 part.

BEST PEWTER.

Tin, 100; antimony, 17 parts.

A METAL THAT EXPANDS IN COOLING.

Lead, 9; antimony, 2; bismuth, 1 part. This metal is very useful in filing small defects in iron castings, &c.

QUEEN'S METAL.

Tin, 9; antimony, 1; bismuth, 1; lead, 1 part.

MOCK PLATINUM.

Brass, 8; zinc, 5 parts.

MOCK GOLD.

Fuse together copper, 16; platinum, 7; zinc, 1 part. When steel is alloyed with 1-500 part of platinum, or with 1-500 part of silver, it is rendered much harder, more malleable, and better adapted for every kind of cutting instrument.

NOTE.—In making alloys, care must be taken to have the more infusible metals melted first, and afterwards add the others.

COMPOSITION USED IN WELDING CAST STEEL.

Borax, 10; sal ammoniac, 1 part; grind or pound them roughly together; then fuse them in a metal pot over a clear fire, taking care to continue the heat until all spume has disappeared from the surface. When the liquid appears clear, the composition is ready to be poured out to cool and concrete; afterwards being ground to a fine powder, it is ready for use. To use this composition, the steel to be welded is raised to a heat which may be expressed by "bright yellow;" it is then dipped among the welding powder, and again placed in the fire until it attains the same degree of heat as before, it is then ready to be placed under the hammer.

CAST IRON CEMENT.

Clean borings, or turnings, of cast iron, 16; sal ammoniac, 2; flour of sulphur, 1 part; mix them well together in a mortar and keep them dry. When required for use, take of the mixture 1; clean borings, 20 parts; mix thoroughly, and add a sufficient quantity of water. A little grindstone dust added improves the cement.

FLUID FOR TINNING IRON, COPPER, BRASS AND ZINC.

To 1 quart of muriatic acid add small pieces of zinc, until bubbles cease to rise; add 2 ounces ground sal ammoniac. For tin add 2 parts water.

STRENGTH OF MATERIALS.

[*From Grier's Mechanic's Calculator, &c.*]

Bar of Iron.—The average breaking weight of a Bar of Wrought Iron, 1 inch square, is 25 tons; its elasticity is destroyed, however, by about two-fifths of that weight, or 10 tons. It is extended within the limits of its elasticity, .000096, or one-ten-thousandth part of an inch for every ton of strain per square inch of sectional area. Hence, the greatest constant load should never exceed one-fifth of its breaking weight or 5 tons for every square inch of sectional area.

The lateral strength of wrought iron, as compared with cast iron is as 14 to 9. Mr. Barlow finds that wrought iron bars, 3 inches deep, 11·2 inches thick, and 33 inches between the supports, will carry 4 1-2 tons.

Bridges.—The greatest extraneous load on a square foot is about 120 pounds.

Floors.—The least load on a square foot is about 160 pounds.

Roofs.—Covered with slate, on a square foot, 51 1-2 pounds.

Beams.—When a beam is supported in the middle and loaded at each end, it will bear the same weight as when supported at both ends and loaded in the middle; that is, each end will bear half the weight.

Cast Iron Beams should not be loaded to more than one-fifth of their ultimate strength.

The strength of similar *beams* varies inversely as their lengths; that is, if a beam 10 feet long will support 1000 pounds, a similar beam 20 feet long would support only 500 pounds.

A *beam* supported at one end will sustain only one-fourth part the weight which it would if supported at both ends.

When a *beam* is fixed at both ends, and loaded in the middle, it will bear one-half more than it will when loose at both ends. When the beam is loaded uniformly throughout it will bear double. When the beam is fixed at both ends, and loaded uniformly, it will bear triple the weight.

In any *beam* standing obliquely, or in a sloping direction, its strengh or strain will be equal to that of a beam of the same breadth, thickness, and material, but only of the length of the horizontal distance between the points of support.

In the construction of *beams*, it is necessary that their form should be such that they will be equally strong throughout. If a beam be fixed at one end, and loaded at the other, and the breadth uniform throughout its length, then, that the beam may be equally strong throughout, its form must be that of a parabola. This form is generally used in the beams of steam engines.

When a *beam* is regularly diminished towards the points that are least strained, so that all the sections are similar figures, whether it be supported at each end and loaded in the middle, or supported in the middle and loaded at each end, the outline should be a cubic parabola.

When a beam is supported at both ends, and is of the same breadth throughout, then, if the load be uniformly distributed throughout the length of the beam, the line bounding the compressed side should be a semi-ellipse.

The same form should be made use of for the rails of a wagon way, where they have to resist the pressure of a load rolling over them.

Similar *plates* of the same thickness, either supported at the ends or all round, will carry the the same weight either uniformly distributed or laid on sinilar points, whatever be their extent.

The lateral strength of any *beam*, or *bar* of *wood*, *stone*, *metal*, &c., is in proportion to its breadth multiplied by depth¾. In square beams the lateral strengths are in proportion to the cubes of the sides, and in general of like-sided beams as the cubes of the similar sides of the section.

The lateral strength of any *beam* or *bar*, one end being fixed in the wall and the other projecting, is inversely as the distance of the weight from the section acted upon; and the strain upon any section is directly as the distance of the weight from that section.

The absolute strength of *ropes* or *bars*, pulled lengthwise, is in proportion to the squares of their diameters. All cylindrical or prismatic rods are equally strong in every part, if they are equally thick, but if not they will break where the thickness is least.

The strength of a *tube*, or *hollow cylinder*, is to the strength of a solid one as the difference between the fourth powers of the exterior and interior diameters of the tube, divided by the exterior diameter, is to the cube of the diameter of a solid cylinder,—the quantity of matter in each being the same. Hence, from this it will be found, that a hollow cylinder is one-half stronger than a solid one having the same weight of material.

The strength of a column to resist being crushed is directly as the square of the diameter provided it is not so long as to have a chance of bending. This is true in metals or stone, but in timber the proportion is rather greater than the square.

MODELS PROPORTIONED TO MACHINES.

The relation of models to machines, as to strength, deserves the particular attention of the mechanic. A model may be perfectly proportioned in all its parts as a model, yet the machine, if constructed in the same proportion, will not be sufficiently strong in every part; hence, particular attention should be paid to the kind of strain the different parts are exposed to; and from the statements which follow, the proper dimensions of the structure may be determined.

If the strain to draw asunder in the model be 1, and if the structure is 8 times lager than the model, then the stress in the structure will be 8¾ equal 512. If the structure is 6 times as large as the model, then the stress on the structure will be 6¾ equal 216, and so on; therefore, the structure will be much less firm than the model; and this the more, as the structure is cube times greater than the model. If we wish to determine the greatest size we can make a machine of which we have a model, we have.

The greatest weight which the beam of the model can bear, divided by the weight which it actually sustains equal a quotent which, when multiplied by the size of the beam in the model, will give the greatest possible size of the same beam in the structure.

Ex.—If a beam in the model be 7 inches long, and bear a weight of 4 lbs. but is capable of bearing a weight of 26 lbs.; what is the greatest length which we can make the corresponding beam in the structure? Here

$$26 \div 4 = 6\cdot5, \text{ therefore, } 6\cdot5 \times 7 = 45\cdot5 \text{ inches.}$$

The strength to resist, crushing increases from a model to a structure in proportion to their size, but, as above, the strain increases as the cubes; wherefore, in this case, also, the model will be stronger than the machine, and the greatest size of the structure will be found by employing the square root of the quotient in the last rule, instead of the quotient itself; thus,

If the greatest weight which the column in a model can bear is 3 cwt., and if it actually bears 28 lbs., then, if the column be 18 inches high, we have

$$\sqrt{\left(\frac{336}{28}\right)} = 3\cdot564\text{; wherefore } 3\cdot464 \times 18 = 62\cdot352$$

inches, the length of the column in the structure.

[*From Adcock's Engineer.*]

List of metals, arranged according to their strength.—Steel, wrought-iron, cast-iron, platinum, silver, copper, brass, gold, tin, bismuth, zinc, antimony, lead,

According to Tredgold's and Duleau's experiments, a piece of the best bar-iron 1 square inch across the end would bear a weight of about 77.373 lbs., while a similar piece of cast-iron would be torn asunder by a weight of from 16,243 to 19,464 lbs. Thin iron wires, arranged parallel to each other, and presenting a surface at their extremity of 1 square inch, will carry a mean weight of 126,340 lbs.

List of woods, arranged according to their strength.—Oak, alder, lime, box, pine (*sylv.*), ash, elm, yellow pine, fir.

A piece of well-dried pine wood, presenting a section of 1 square inch, is able, according Eytelwein, to support a weight of from 15,646 lbs. to 20,408 lbs., whilst a similar piece of oak will carry as much as 25,850 lbs.

Hempen cords, twisted, will support the following weights to the *square inch* of their section:

½ inch to 1 inch thick, 8,746 lbs.; 1 to 3 inches thick, 6,800 lbs.; 3 to 5 inches thick, 5,345 lbs.; 5 to 7 inches thick, 4,860 lbs.

Tredgold gives the following rule for finding the weight in lbs. which a hempen rope will be capable of supporting: Multiply the square of the circumference in inches by 200, and the product will be the quantity sought.

In the practical application of these measures of absolute strength, that of metals should be reckoned at one-half, and that of woods and cords at one-third of their estimated value.

In a parallielopipedon of uniform thickness, supported on two points and loaded in the middle, *the lateral strength is directly as the product of the breadth into the square of the depth, and inversely as the length.* Let W represent the lateral strength of any material, estimated by the weight, b the breadth, and d the depth of its end, and l the distance between the points of support; then $W = f d^2 b \div 4l$.

If the parellelopipedon be fastened only at one end in a horizontal position, and the load be applied at the opposits end, $W = f d^2 b \div 4l$.

It is to be observed that the three dimensions, b, d, and l, are to be taken in the same measure, and that b be so great that no lateral curvature arise from the weight: f in each formula represents the lateral strength, which varies in different materials, and which must be learnt experimentally.

A beam having a rectangular end, whose breadth is two or three times greater than the breadth of another beam, has a power of suspension respectively two or three times greater than it; if the end be two or three times deeper than the end of the other, the suspension power of that which has the greater depth exceeds the suspension power of the other, four or nine times; if its length be two or three times greater than than the length of another beam, its power of suspension will be ½ 1-3 respectively that of the other; provided that in each case the mode of suspension, the position of the weight, and other circumstances be similar. Hence it follows that a beam, one of whose sides tapers, has a greater power of suspension if placed on the slant than on the broad side, and that the powers of suspension in both cases are in the ratio of their sides; so, for instance, a beam, one of whose sides is double the width of the other, will carry twice as much if placed on a narrow side, as it would if laid on the wide one.

In a piece of round timber (a cylinder) the power of suspension is in proportion to the diameters cubed, and inversely as the length; thus a beam with a diameter two or three times longer than that of another, will carry a weight 8 or 27 times heavier respectively than that whose diameter is unity, the mode of fastening and loading it being similar in both cases.

The lateral strength of square timber is to that of a tree whence it is hewn as 10 : 17 nearly.

A considerable advantage is frequently secured by using hollow cylinders instead of solid ones, which, with an equal expenditure of materials, have far greater strength, provided only that the solid part of the cylinder be of a sufficient thickness, and that the workmanship be good; especially that in cast metal beams the thickness be uniform, and the metal free from flaws. According to Eytelwein, such hollow cylinders are to solid ones of equal weight of metal as 1.212 : 1, when the inner semi-diameters is to the outer as 1 : 2;

according to Tredgold as 17 : 10, when the two semi-diameters are to each other as 15 : 25, and as 2 : 1, when they are to each other as 7 : 10.

A method of increasing the suspensive power of timber supported at both ends, is, to saw down from ¼ to ⅓ of its depth, and forcibly drive in a wedge of metal or hard wood, until the timber is slightly raised at the middle out of the horizontal line. By experiment it was found that the suspensive power of a beam thus cut 1-3 of its depth was increased 1-19th, when cut ½ it was increased 1-29th, and when cut 3-4th through it was increased 1-87th.

The force required to crush a body increases as the section of the body increases; and this quantity being constant, the resistance of the body diminishes as the height increases.

According to Eytelwein's experiments, the strength of columns or timbers of rectangular form in resisting compression is, as

1. The cube of their thickness (the lesser dimension of their section). 2. As the breadth (the greater dimension of their section). 3. inversely as the square of their length.

Cohesive power of Bars of Metal one inch square, in Tons.

Iron, Swedish bar	29.20	Copper, wrought	15.80
Do., Russian bar	26.70	Gun metal	16.23
Do., English bar	25.00	Copper, cast	8.51
Steel, cast	59.93	Brass, cast, yellow	8.01
Do., blistered	59.43	Iron, cast	7.87
Do., sheer	56.97	Tin, cast	2.11

Relative Strength of Cast and Malleable Iron.

It has been found, in the course of the experiments made by Mr. Hodgkinson and Mr. Fairbairn, that the average strain that cast iron will bear in the way of tension, before breaking, is about seven tons and a half per square inch; the weakest, in the course of 16 trials on various descriptions, bearing 6 tons, and the strongest 9 3-4 tons. The experiments of Telford and Brown show that malleable iron will bear, on an average, 27 tons; the weakest bearing 24, and the strongest 29 tons. On approaching the breaking point, cast iron may snap in an instant, without any previous symptom, while wrought iron begins to stretch, with half its breaking weight, and so continues to stretch till it breaks. The experiments of Hodgkinson and Fairbairn show also that cast iron is capable of sustaining compression to the extent of nearly 50 tons on the square inch; the weakest bearing 36½ tons, and the strongest 60 tons. In this respect, malleable iron is much inferior to cast iron. With 12 tons on the square inch it yields, contracts in length, and expands laterally; though it will bear 27 tons, or more, without actual fracture.

Rennie states that cast iron may be crushed with a weight of 93,000 lbs., and brick with one of 562 lbs. on the square inch.

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APPLICATION OF SHADOWS TO TOOTHED GEAR, Plate XXX. *Application of Shadows to Screws*, Plate XXXI. *Application of Shadows to a Boiler and its Furnace*, Plate XXXII. *Shading in Black—Shading in Colors*, Plate XXXIII.

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